DEFORMITIES

INCLUDING

SEASES OF THE BONES AND JOINTS

VOLUME I

CONGENITAL AND STATIC DEFORMITIES
INJURIES AND DISEASES OF MUSCLES, TENDONS
BURSÆ AND FASCLÆ

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DEFORMITIES

INCLUDING

DISEASES OF THE BONES AND JOINTS

A TEXT-BOOK OF ORTHOPÆDIC SURGERY

BY

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TO CHRIST'S HOSPITAL AND TO THE SEVENOAKS HOSPITAL FOR HIP DISEASE
CORRESPONDING MEMBER, AMERICAN ORTHOPEDIC ASSOCIATION

SECOND EDITION

ILLUSTRATED BY 70 PLATES AND OVER 1000 FIGURES, OF WHICH NEARLY 400 ARE ORIGINAL, AND BY NOTES OF 54 CASES

IN TWO VOLUMES

VOL. I

MACMILLAN AND CO., LIMITED
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TO

MY WIFE

PREFACE TO THE SECOND EDITION

During the time, which has elapsed since the publication of the first edition of this work, immense progress has been made in Orthopædic Surgery. New methods of treatment, based on clearer conceptions of pathogenesis and rendered possible by recent advances in *technique*, have come into vogue, and in a measure have supplanted the older ones. The special literature of the subject, apart from articles in periodicals devoted to General Surgery, has in recent years become very extensive: Journals of Orthopædic Surgery and Transactions being regularly published in America, Germany, France, and Italy. These considerations, combined with the solicitations of friends, who have been kind enough to express approval of my efforts in the production of the First Edition, induced me to undertake the preparation of these volumes. If, when I began, I had fully appreciated the magnitude and difficulty of the task, it is probable that my courage would have failed. However, the interest inherent in the subject, the fact that there is no recent British work dealing fully with it, combined with the stimulating effect of the accounts of recent developments, have kept my energy from flagging, and enabled me to complete this account of Orthopædic Surgery as it stands to-day. With what measure of success the task has been performed is a matter for others to judge.

At the outset it was apparent that the entire work would need re-writing, and that any attempt merely to re-edit it would be courting failure. Having come to this decision, I was enabled to follow a plan which had been long under consideration, namely,

the grouping and arrangement of the various subjects on ætiological and pathological bases, in preference to the less scientific regional classification, adopted in the first edition. Thus, one section is now devoted to deformities of congenital origin, another to those arising from static conditions, a third to paralytic deformities, and so on, the subject being completed in ten sections.

In England, contrary to the custom abroad, works written on "Orthopædic Surgery," although they have dealt with tuberculosis of the spine, have not included tuberculous and many other forms of diseases of the bones and joints elsewhere. And this, in spite of the obvious fact that in the practice of Orthopædic Surgery a surgeon is constantly called upon to deal with such morbid conditions and their results. It has been my attempt to remedy this somewhat illogical state of affairs, and to treat the subject from its actual standpoint, which is the surgery of the entire locomotor apparatus, dealing not only with actual deformities, but also with those morbid processes which involve potential deformity. It is not claimed that the scope of the orthopædic surgeon's work is thereby enlarged, since he undertakes already the treatment of malformations and deformities of the muscular and osseous systems, which demands a full acquaintance with the pathology of such conditions and with the essential therapeutic methods. A considerable portion of the work has therefore been devoted to a description of arthritic and osseous diseases, as indicated by the amplification of the former title into "Deformities, including Diseases of the Bones and Joints, a Text-Book of Orthopædic Surgery."

The amount of material has proved such that the work is now issued in two volumes, as being more convenient to handle; and an index of the whole subject-matter and of authors quoted is included in each volume.

A work dealing with departures from normal form and structure requires numerous illustrations in order to render the text clear. There are 70 plates and more than 1000 Figures in all, of which

nearly 400 are original. I take this opportunity of thanking all those authors and publishers who have accorded me the privilege of reproducing such illustrations as were deemed necessary. In every instance it has been my endeavour to make due acknowledgment of the source whence the figures are derived; and, if there has been a failure in any one instance, I beg to tender my apologies. My thanks are due to my friends Mr. C. Thurstan Holland of Liverpool and Dr. Alban Köhler, who have supplied me with excellent negatives for some of the Röntgen-ray plates. To Messrs. Macmillan, my ever-considerate and kind publishers, my gratitude is due for their liberality in allowing me so many illustrations, and for the care they have taken in the making up of the volumes.

To two friends in particular I desire to express my hearty acknowledgments for all the help and assistance they have given me. Mr. C. E. Groves, F.R.S., has been so good as to read the slip- and final proofs, and has made many suggestions, which it is hoped may add to the literary value of the work. To my old friend Mr. Vincent Moxey, formerly Registrar at the National Orthopaedic Hospital, I tender the fullest possible tribute for the aid he has, in so unstinted and generous a manner, given me. Upon him has devolved the task of consulting the works of British and foreign writers and making abstracts from the Transactions and Journals. He cheerfully undertook this labour and was enthusiastic in carrying it out. The number of references in the footnotes bears evidence to the thoroughness of his work; and, during its progress, I was frequently able to avail myself of his valuable advice. He has also been most kind in correcting the proof-sheets. Without his help and that of other friends I am convinced it would have been entirely impossible for me to have accomplished the work and to bring its details up to date.

A. H. TUBBY.

68 HARLEY STREET, LONDON, W.

January 1912.

PREFACE TO THE FIRST EDITION

THIS volume is the outcome of several years' work at the National Orthopædic Hospital, the Evelina Hospital for Sick Children, and for a shorter time in the Orthopædic Department at the Westminster Hospital. Almost all the cases quoted are from my note-books, and 200 of the illustrations have been drawn from my patients specially for this work. The observations on the "Repair of Tendons," a subject so ably handled by Mr. Adams several years ago, have been repeated by me with the aid of more recent histological methods. It has been my endeavour to make myself acquainted, by direct observation, with the methods of treatment practised in Orthopædic Clinics abroad as well as at home, so that most of the details have been personally verified.

The object, however, of this treatise is not only a record of one's own work, but also to give a succinct account of our knowledge on the subject of "Deformities." I have not, therefore, hesitated to avail myself of the writings of Bradford and Lovett, published in America; of Rédard in France; of Hoffa in Germany; of Adams, Reeves, Walsham and Hughes in this country. Above all, I cannot omit to express my sense of indebtedness to the many admirable writers who have recorded their experiences in the *Transactions of the American Orthopedic Association.*

Some of the material has from time to time appeared in the pages of the *Hospital*, and I have to acknowledge the permission of the editor of that journal to reproduce it here.

In the matter of Plates and Figures, my best thanks are due to

Mrs. E. Davis and Mr. Prendergast Parker, for the care with which they have made the drawings; to Mr. F. Gustav Ernst, for permission to make use of many of the illustrations in his work on Orthopædic Apparatus; and to my publishers, Messrs. Macmillan, for the liberality with which they have met my wishes for a fully illustrated volume.

To Mr. Vincent Moxey and to Mr. W. Spencer Payne I am grateful for valuable suggestions and assistance in seeing the work through the press.

The practice of Orthopædic Surgery in England does not include all phases of diseases of the bones and joints, such as tubercular ostitis and arthritis of the hip and knee, on what grounds it is difficult to understand; nor, in such a work as this would it be customary to write on many congenital deformities, such as cleft palate and hare-lip, which are within the domain of Plastic Surgery.

That this volume may be a reliable guide to medical men in the treatment of deformities, and to advanced students in the understanding of a somewhat difficult branch of surgery, is the wish of

THE AUTHOR.

25 Weymouth Street, Portland Place, W.
June 1896.

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INTRODUCTION

ORTHOPÆDIC Surgery, like other special branches of surgery, has no definite limits. Andry, to whom the word "orthopaedic" is due, evidently, from the etymology of the word—ὀρθός, "straight," and παῖς, "child"—and from the scope of his writings, had almost exclusively in mind deformities met with in early life, and those associated with growth. His idea of age limitation is seen from the title he selected—*L'Orthopédie ou l'art de prévenir et de corriger dans les enfants, les difformités du corps.* It is clear that such a conception of "orthopaedics" is at this time too restricted; and in a measure the word itself is unfortunate, for senile kyphosis is just as much an orthopaedic condition, as is the rachitic kyphosis of infancy.

Yet the mere presence of deformity does not necessarily bring a case within the scope of orthopaedic surgery. For example, herniæ, cleft palate, and extroversion of the bladder are not orthopædic conditions, although on the Continent the tendency is, in some quarters, to cast the net pretty widely. The individual surgeon will regulate his practice as he sees fit, but it is a pity to occupy space in special orthopædic publications with material of more general interest.

Orthopædic surgery, then, although it is essentially the Surgery of Deformities, does not include the surgical treatment of every malformation; and since Andry's day *l'art de prévenir* has become quite as important as correction and restitution.

Not only are the researches of orthopædic surgeons fertile in preventing deformity of the growing child, but the experience thus gained is further available in the treatment of malposition following inflammatory and destructive lesions and paralysis. The orthopædic surgeon is called upon to treat contractures resulting from disease of a joint, and he naturally studies the prophylaxis of such conditions and the methods of directly attacking the disease.

This position has been fully recognised for some time abroad, and with excellent results. In England, however, whilst it was regarded as suitable that the orthopædic surgeon should treat tuberculous disease of the spine, he was not expected, for example, to handle a knee damaged by the same infective process until the requisite degree of deformity had been allowed to develop! Again, there may be no deformity in the crude sense of the word, yet a deformity of function may exist. Thus limitations of movement due to slight contracture or fibrous ankylosis are orthopædic conditions.

On the whole, the scope of modern Orthopædic Surgery may be fairly described as comprising the surgery of deformities of the apparatus of locomotion in all three aspects—ætiological, prophylactic, and therapeutic.

With so wide a field, it is clear that abstruse discussion on the nature of deformity is of little use, because the conditions with which deformity is associated are so varied and diverse. Thus there is little relationship between "static" deformities of adolescence, deformities due to disease, and those of congenital origin. The fact is, "deformity" is not an entity, and suggestions as to its "nature," apart from ætiological groupings, are waste of words. On the other hand, in dealing with definite lesions, such as congenital club-foot, there is ample scope for speculation as to the origin of the condition. Formerly, when the range of orthopædics was more limited, the great group of static deformities, seen chiefly in later childhood, loomed relatively very large, and discussions as to the truth of the "Belastungs," or pressure-theory, *versus* its partial supplanter, the theory of the functional pathogenesis of deformity, appeared of more fundamental importance than they do at present. We do not mean that the views of Volkmann and Hueter, and those of Julius Wolff and his school, do not call for close examination, but that their immediate bearing applies only to a portion of the subject-matter comprising orthopædics as now constituted. At the same time the bearing of the doctrine of functional pathogenesis on methods of treatment must not be under-estimated.

Ætiologically, deformities are classified as either congenital or acquired. The congenital are either primary or secondary, the latter differing in no way from similar conditions arising in post-natal life. An example may make this clear. Continuous fixation of a part in a given position leads to a corresponding structural moulding—a foot retained long enough in a varus position

becomes varoid, and this holds equally true in both ante- and post-natal existence. If, during intra-uterine life for any reason, the foot is held continuously in a varus position, a congenital club-foot of secondary origin is produced. This process is often spoken of as being due to intra-uterine malposition, an unfortunate phraseology, since the fixation and retention in that position cause the trouble, and not the malposition. Striking examples of this purely mechanical origin are afforded by cases, recorded of club-foot, arising under the abnormal conditions of extra-uterine pregnancy.

Typically primary congenital cases are the hereditary deformities, such as club-foot, transmitted through the male side. The ultimate causation here is at present speculative. Atavism, in the direction of a prehensile toe, has been suggested, an explanation not entirely far-fetched, for both here and elsewhere, as in congenital scoliosis and Sprengel's shoulder, speculations based on phylogenetic considerations have a place. Nearly related to atavistic conditions are malformations sometimes spoken of as arrest of development. Observers, also, who have made a study of ante-natal pathology believe that tuberculosis and alcoholism in the parents may affect the germ, and be a direct cause of primary malformations. Pending fuller knowledge, we speak, in primary congenital deformities, of a fault in the germ itself—a *vitium primae formationis.*

But a congenital deformity may be neither primary nor secondary in the above senses, in which secondary relates to extra-fœtal influences altogether, and primary to the deformity itself; it may still be secondary to some affection of the fœtus elsewhere. Thus club-foot may be secondary to malformations of the spinal cord, as in spina bifida. The presence of multiple congenital anomalies sometimes assists the conception of the underlying process, and sometimes obscures it. For example, the coincidence of club-foot and constriction by bands points to a mechanical origin, whilst club-foot coexisting with harelip or extroverted bladder is of more problematical causation. Lastly, congenital deformity may arise from fœtal disease, as fœtal rickets, chondrodystrophia, or osteogenesis imperfecta.

A congenital deformity is not necessarily obvious at birth. A scoliosis due to a vertebral anomaly is strictly congenital, yet it may not be evident until late in childhood. The tendency to congenital dislocation of the hip may be present, but the actual dislocation is delayed until the child attempts to walk.

These brief remarks are merely intended to give a glimpse of

the nature and extent of the problems involved, and fuller consideration of the individual conditions will be given in the body of this work. We speak here with similar reservation of the acquired deformities. It is not now intended to give a full and inclusive classification, but merely to deal with them on broad lines, indicative of their general character.

The bulk of acquired deformities may be classed as:—

1. Static.
2. Dependent on processes of bony softening.
3. Due to inflammatory and destructive lesions of bones or joints.
4. Traumatic.
5. Dependent on paralysis, spasm, or contracture of muscles.

1. *Static.*—Many of the deformities seen in adolescents, such as scoliosis, coxa vara, genu valgum, flat-foot, are unaccompanied by any demonstrable pathological process in the parts concerned, and observers are compelled to fall back on more purely mechanical theories of causation—a point of view indicated by the designation "static." Now, useful as the word "static" is here, it must not be forgotten that mechanical laws come into play just the same in the definitely pathological groups of deformities, only in them the pathological factors mainly absorb attention. Therefore there is, in the nature of things, considerable ætiological overlapping, and often it must depend on the point of view of the individual observer as to where a given condition is placed. For instance, a scoliosis, becoming marked first in early adult life, may be ultimately traced to infantile rickets, yet in reality many years of entire freedom from rachitic softening having intervened, the factors governing the case are almost purely static. Also in using the word "static" we must bear in mind that we are not dealing with dead, inert material, but living matter, capable of reaction, and subject to the laws of growth. It is here especially that the partisans of Wolff's views—that is, the defenders of the doctrine of the functional pathegenesis of deformity—seek to revolutionise the more purely mechanical theories of the results of pressure, as enunciated by Volkmann and Hueter. We shall deal elsewhere more fully with Wolff's so-called law.

Very briefly put, Wolff taught that form is the outcome of function, and that a continuous or sufficiently frequent performance of function in a given position is followed by or associated with a corresponding structural change and adaptation. Regarded from a broad biological point of view, such a proposition is almost a

truism, as is seen in the structural adaptations in passing from the quadrupedal or quadrumanal to the bipedal types, although here one is constantly met with the difficulty as to which is cause and which effect. But when it is sought to maintain that the process takes place, and with mathematical accuracy, in the course of the life history of an individual, the subject of a deformity—and, by the way, the deformity in this view is really no deformity at all, but the best possible form under the circumstances—great difficulties arise. For example, it is strange, if Wolff is correct, why some should adapt and others not. Thus an oblique pelvis may exist for years without setting up a structural scoliosis. One point much in favour of Wolff's position is that a true "functional" group of scoliosis does exist associated with certain callings. Whether or not we accept Wolff's views, the effect of continuous passive pressure cannot be entirely excluded. The observations of Humphry, Arbuthnot Lane, and others, as to matters of fact on this point still hold good.

2. *Examples of bony softening* are rickets and osteomalacia. The deforming process may be due primarily to the superincumbent weight, as in rachitic scoliosis, kyphosis, knock-knee, and bow-legs; or the unsupported weight of the part itself, as in certain anterior curves of the tibia developing before the infant attempts to walk. We are not, however, dealing merely with the mechanical effect of overloading and of insufficient resistance and support, for in all cases the deforming factor of muscular action comes into play. In scoliosis, the tension of the longitudinal spinal muscles, in anterior curves of the femur and tibia, the preponderating influence of the hamstrings and calf muscles act their parts. Good examples of the effect of the interplay between pressure and muscular pull, the bones being soft, are seen in the rachitic thorax and pelvis. After the softening process passes off, a more or less perfect recovery of form may ensue if the muscles are properly trained.

3. *In inflammatory and destructive lesions* many deforming factors are concerned: muscular spasm, loss of substance, mechanical distension, and eventually contractural conditions with fibrous and osseous ankylosis. Tuberculous spondylitis and spondylarthritis are accompanied by a deformity which is modified by spasm of the spinal muscles, and in the dorsal region is directly related to loss of substance. Lameness in these diseases may be due to mechanical distension of the psoas sheath by an abscess, which may be followed by psoas contracture, and the spinal deformity be eventually limited

by osseous ankylosis. *Pari passu* with the primary deforming process, a secondary deformation in the reverse sense is progressing in other regions, so as to compensate spontaneously and instinctively for the primary change.

4. *Purely traumatic conditions*, such as malunited fracture or unreduced dislocation, rarely come under the care of the orthopædic surgeon. There is, however, a possibility that some cases of congenital dislocation of the hip are really traumatic during birth. Hæmatoma of the sterno-mastoid and its bearing on congenital wry-neck is another traumatic condition calling for consideration. The traumatic element in Pott's disease, and the possibility of a purely traumatic gibbosity, as at one time suggested by Kümmell, and cases of traumatic genu valgum and flat-foot, are sufficient to justify the retention of "traumatic," ætiologically.

5. In *paralysis* we witness the mere mechanical effect of attempting to support weight on a more or less flail-like part, as in paralytic genu valgum and flat-foot. Or, the deforming effect of the weight of the part itself comes into play as in some paralytic dropped feet; and in partial paralysis, the results of unbalanced muscular action, as in paralytic varus. In addition to them are the effects of trophic wasting, wasting from disease, and retardation of growth of the part. In spastic paraplegia the deformation is largely due to the overpowering of the weaker by the stronger muscles, or more correctly the overpowering by those whose action is more effective. Excluding the question of the absolute strengths of the adductors and abductors of the thighs, it is clear that the former being inserted so far away from the pelvis at the lower end of the femur have a great advantage over the abductors inserted nearer the hips—hence the preponderance of adductor contracture. Perhaps, too, certain movements such as flexion and adduction are in themselves more primitive and less highly educational than extension and abduction, and are therefore liable to preponderate when the central control is disturbed or lessened.

This is a convenient place to say a few words about contracture, since at various times it has been thought that this process was fundamentally nervous in character. It is true that a more or less permanently actively contracted muscle becomes eventually structurally shortened, as the sterno-mastoid in spasmodic torticollis, the adductors in spastic paraplegia, or the tibiales in paralytic varus. We may also remark in reference to the last that a healthy muscle opposed only by a paralysed one, is in much the same condition as

an actively contracted one; there is soon no "slack" left to be taken up, and actual shortening begins. A few examples such as these, however, do not justify the general view taken by Delpech, Duchenne, Eulenburg, and others, that many deformities and a large number of contractural conditions are ultimately of nervous origin. If we take such an instance as the great structural shortening often met with in the adductors in congenital dislocation of the hip, or the muscular shortening seen in the concavity of a severe rachitic scoliosis, there is in them no suggestion of a nervous origin. The muscular contracture is only one factor of contracture in general, for ligamentous and fascial structures are shortened too, and there is no evidence of any "active" process in these cases.

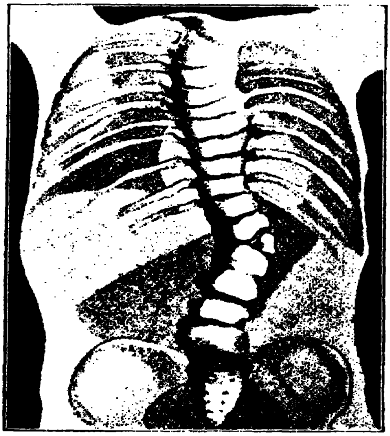
The fact is, attention is often directed too much to the condition of the bones and joints on the one hand, or to the muscles alone on the other. The bones are less "resistant" than is often thought, and the soft parts as a whole much more so. Osseous structure is peculiarly plastic. Again and again we see the limit set to a deforming process by the resistance set up by the soft parts, whereas there seems hardly any length to which deformation of the bones may not go—as is seen, apart from any definite pathological condition, in severe cases of constitutional scoliosis. The resistance of the soft parts, whilst on the one hand it may limit the extent of a deformity, on the other hand perpetuates it by adaptive, nutritional, structural shortening, that is by contracture.

It is clear, then, from the wide nature of the subjects involved, and from the variety and profundity of the speculations and theories to be considered, that orthopaedic surgery is no narrow speciality to be limited by the custom of one nation or another, but is a most important branch of surgical science, and worthy of the closest attention.

SECTION I

DEFORMITIES OF CONGENITAL ORIGIN

PLATE I.



Congenital Scoliosis in a girl, aged 2 years. Interposition of a Wedge-shaped Mass on the left side between the First and Second Lumbar Vertebræ (Mouchet).

To face p

CHAPTER I

CONGENITAL DEFORMITIES OF THE TRUNK

Congenital Abnormalities of the Vertebral Column—Spina Bifida—Cervical Ribs, Congenital Defects of the Spine, and Congenital Scoliosis—Congenital Deficiency of the Clavicles and Ribs—Funnel Chest—Absence of Pectoral Muscles—Congenital Elevation of the Scapula, Sprengel's Shoulder.

CONGENITAL DEFORMITIES OF THE VERTEBRAL COLUMN

WITH the exception of spina bifida, very little attention was paid to these malformations until the discovery of the Röntgen rays, although a few specimens existed in museums.

We are now able to classify the congenital deformities of the spinal column, and this has been done by Perrone[1] in a paper on congenital scoliosis. We do not, however, propose to deal here fully with that subject, because it is more convenient from a clinical point of view to consider it with scoliosis in general (Vol. I. pp. 461-465).

Congenital abnormalities of the spine are grouped thus:—

I. **Vertebral Deformities without Malformation of Other Parts.**—This class comprises (1), Increase in the number of vertebræ; (2), Deficiency of them or of parts of them; (3), Synostosis.

II. **Vertebral Deformities with Malformation of Other Parts,** such as fusion of ribs, suppression of portions of ribs, Sprengel's shoulder, cervical ribs.

I. (1) *Increase in the Number of Vertebræ.*—Examples of this sub-class are: Four supernumerary half-vertebræ found in the spine of a woman aged 46 years[2] (Rokitansky). Thirteen dorsal

[1] *Zeitschr. f. orth. Chir.* xv. 2 bis 4 Hefte, 1906.

[2] Rokitansky, *Handbuch der spez. Anat.* Bd. ii., Wien, 1844.

vertebræ are present, but the third and fourth lumbar vertebræ were only partly developed, and synostosed into a wedge-shaped piece[1] (Meyer). In a girl aged 2 years, a radiogram showed a supernumerary wedge-shaped imperfect vertebra on the left side between the first and second lumbar vertebræ[2] (Mouchet, Plate I.). In a case of lumbar scoliosis, five transverse processes existed on the left or concave side, and six on the right side[3] (Codivilla). Also a little girl presented six complete lumbar vertebræ, and between the first and second dorsal vertebræ there was a supernumerary half-vertebra[4] (Calori). G. Reid, in a specimen at St. Thomas's Hospital, observed a supernumerary half-vertebra between the eighth and ninth dorsal. Plate II., Figs. 1, 2, 3, and Fig. 1, taken from Gottstein's case of congenital scoliosis, afford striking illustration of increase in the number of the dorsal and lumbar vertebræ, and alterations in the number of the ribs.

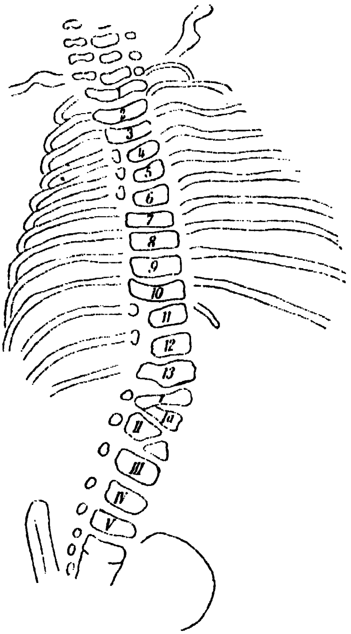


FIG. 1.—Outline Drawing of Radiogram in Plate I. Wedge-shaped pieces of bone are developed between the First and Second and between the Second and Third Lumbar Vertebræ. Thirteen Dorsal Vertebræ are present, also thirteen Ribs on the left, and eleven Ribs on the right side (Gottstein).

(2) *Deficiency of Parts of the Spinal Column.*—This group is more numerous. Rokitansky[5] found in a specimen, taken from a man aged 70 years, one half only of the ninth dorsal vertebra present. Meyer[6] noted in one case that the fifth and sixth dorsal formed a wedge-shaped piece between the fourth and seventh.

[1] Meyer, *Zeitschr. f. rationelle Med.*, 1855, Bd. vi.

[2] A. Mouchet, "Scoliose congén. dorso-lumbaire par pièce vertébrale surnuméraire," *Gaz. heb. de méd. et de chir.*, May 19, 1898. *Bull. Soc. Anat. de Paris*, Nov. 1899, lxxiv. p. 972. A. Mouchet et Broca, *Gaz. hebd. de méd. et chir.*, Paris, 1902, N.S., vii. p. 529.

[3] Codivilla, *Soc. med. chir. de Bologna*, 1901.

[4] Calori, quoted by Nau, *Les Scolioses congén.*, Diss., Paris, 1904.

[5] Rokitansky, *loc. sup. cit.*

[6] Meyer, *loc. sup. cit.*

PLATE II.

FIG. 1.

Posterior view of an infant with Right-sided Congenital Scoliosis (Gottstein).

FIG. 2.

Anterior view of the same infant (Gottstein).

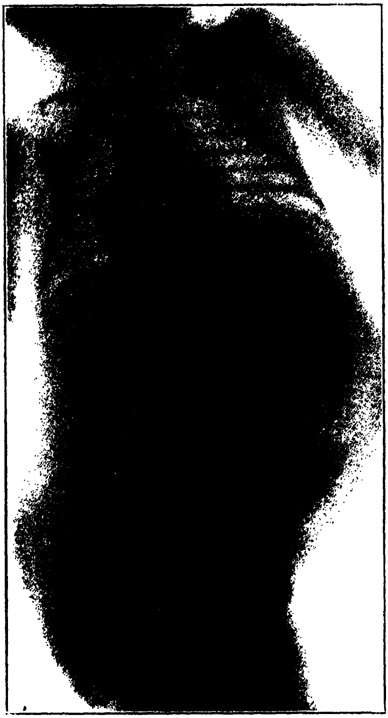


FIG. 3.

Radiogram of a case of Scoliosis, due to Congenital Abnormalities of the Vertebræ and Ribs (Gottstein).

To face page 12.

N. Smith[1] in a woman aged 31 years found that only two cervical, 7½ dorsal, and three lumbar were present, *i.e.* 12½ all told. He[2] also described a spine from a man aged 64 years, with one-half of the first dorsal absent. Then we have those curious examples of congenital spondylolisthesis, where the arch is separated from the body of the fifth lumbar vertebra; and, finally, the numerous cases of spina bifida and spina bifida occulta, where portions or the whole of one or more of the arches are suppressed.

(3) *Synostosis of Vertebral Segments.*—In Meyer's specimen[3] the third and fourth lumbar were only half developed and synostosed as a wedge-shaped piece. In another of N. Smith's[4] cases the third, fourth, and fifth dorsal were welded into one mass. Hirschberger[5] in an adult specimen noted synostosis of the second and third lumbar vertebræ.

Perrone,[6] writing on "Congenital Scoliosis," describes a very usual type of that deformity arising from synostosis of the fifth lumbar vertebra or a part of it with the sacrum. He bases his paper on three specimens in the Pathological Institute at Berlin. In all, the underlying condition was the same, viz. incorporation of the transverse process of the last lumbar vertebra with the lateral mass of the sacrum, an encroachment as it were of the latter upon the lumbar spine. The result is similar to that seen in lateral ankylosis of adjacent segments, a sharp tilting of the spine to the affected side (Figs. 2 and 3). The extent to which the fifth lumbar body is incorporated with the sacrum varies. In one case the bodies were united absolutely, and appeared to form the first sacral segment.

II. **Congenital Abnormalities of the Vertebræ associated with other Deformities.**—Willett and Walsham,[7] in a woman aged 31 years, who suffered from congenital scoliosis, found four and a half dorsal segments present, with five ribs on the right side and four on the left side absent. We shall describe presently examples of this group associated with abnormalities of the ribs, scapula,

[1] *Clinical Sketches*, 1895. Cf. also Fitch, *Amer. Jour. Orth. Surg.* vol. vii. No. 4, May 1910, p. 540.

[2] *Ibid.* Also R. R. Fitch, *Amer. Jour. Orth. Surg.* vol. vii. No. 4, May 1910, describes a case of "Congenital Absence of Vertebræ below the First Sacral, and Malformation of the Lower Cervical and Upper Dorsal Vertebræ."

[3] *Op. sup. cit.* [4] *Op. sup. cit.*

[5] Hirschberger, "Beiträge zur Lehre der angeborenen Skoliosen," *Zeitschr. f. orth. Chir.* Bd. vii. Heft 1.

[6] "Über kongenit. Skoliosis," *Zeitschr. f. orth. Chir.* xv. 2 bis 4 Hefte, 1906.

[7] Willett and Walsham, *Med.-Chir. Trans.* vol. lxiii. p. 257, 1880.

and clavicle. In the case of a lady, of 27 years, from whom we removed a left cervical rib, a supernumerary wedge-shaped vertebra was locked in between the sixth and seventh cervical, and the transverse process of the sixth cervical vertebra was so elongated as

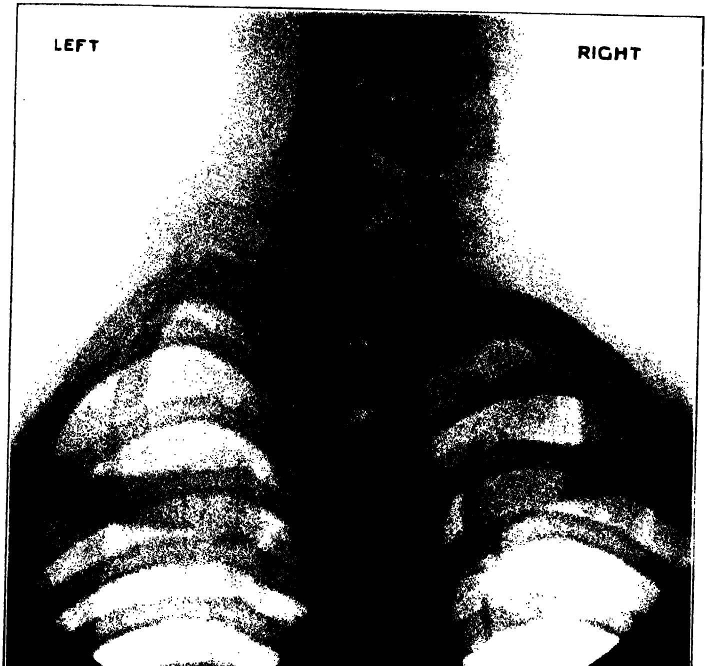
FIG. 2.—Part of the Lumbar Spine and the Pelvis from a case of Congenital Scoliosis The lumbar spine is abruptly curved to the left, the fifth lumbar vertebra is wedge shaped, and its transverse process is fused with the lateral mass of the sacrum—Sacralisation of the last Lumbar Vertebra (Perrone).

FIG. 3.—Posterior view of the Lower Lumbar Vertebræ and of the Pelvis in Figure 2 (Perrone).

almost to constitute another cervical rib on that side (Plates III. and IV.).

The interest of these observations lies in their bearing on the

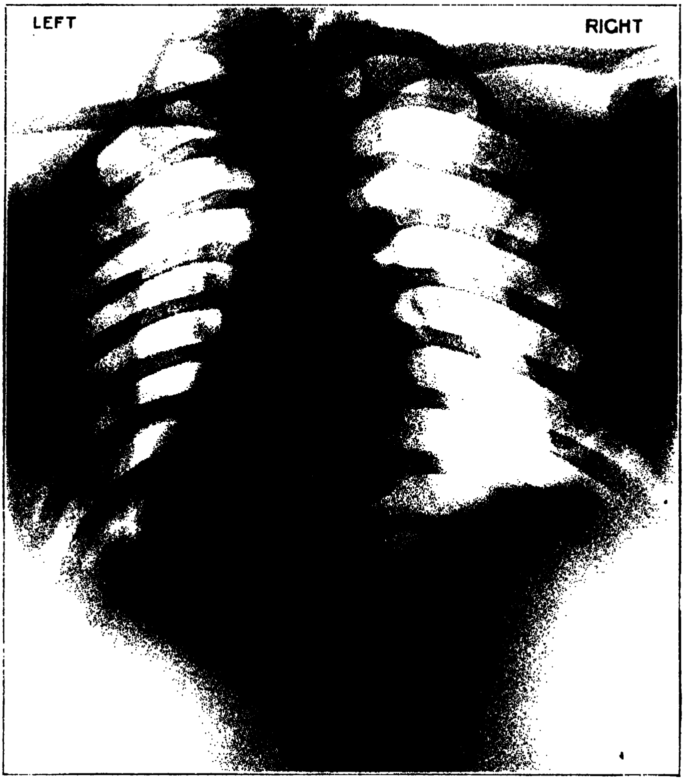
PLATE III.



A Radiogram taken from a female patient, aged 23 years. The view is a posterior one, and shows a well-developed Cervical Rib on the left side, and the Elongation of the Sixth Cervical Transverse Process. Congenital Scoliosis is present in the Cervico-Dorsal and Dorsal Areas.

To face page 14.

PLATE IV.



A Radiogram, posterior view, from the same patient as in Plate III. A Cervical Rib i present on the left side, and the Curvatures in the Spinal Column are fairly evident.

To face page 1

history of some cases of scoliosis. Long ago, William Adams[1] drew attention to congenital and hereditary spinal curvature. And we have only recently learnt to suspect that in cases of abrupt cervico-dorsal and lumbar scoliosis we are very likely to find the cause to be maldevelopment of the column.

Symptoms.—In addition to deformity of the spine, the most usual symptom is pain in the peripheral nerve areas, often succeeded by paralysis of the muscles supplied from nerve roots which are undergoing compression. Frequently a Röntgen ray picture is required before the cause of the pain can be ascertained, and the diagnosis established.

Treatment.—This is referred to in Section III. pp. 531, 532, on "Scoliosis," where it is shown that a curvature of congenital origin is not so refractory as we should expect.

Further References to this Subject

BLAND-SUTTON. Trans. Roy. Med.-Chir. Soc., 1884, p. 157.

FLEURY. "Scoliose congénitale," Diss., Paris, 1901.

P. ATHANASSOW. "Über kongen. Skoliose." Archiv f. orth. Mechan., 1903, Heft 3.

COVILLE. "De la scoliose congén." Rev. d'orth., 1896.

RÉDARD. Traité pratique de chir. orth., Paris, 1892.

J. GUÉRIN. Recherches sur les difformités congén., Paris, 1880.

MAAS. "Ein Fall von angeborener Skoliose." Zeitschr. f. orth. Chir., 1903, Bd. vii.

BONNAIRE. Bull. Soc. Obstét. de Paris, 1894.

FITZWILLIAM. Proc. Roy. Soc. Med., December 1908, vol. ii. No. 2.

NATHANIEL ALLISON. Amer. Jour. Orth. Surg., November 1908, p. 286, with skiagram.

BÖHM. Boston Med. and Surg. Jour., November 22, 1906.

BARDEEN. "Numerical Variation in the Human Adult and Embryo." Anat. Anz., Bd. xxv., 1904.

LOVETT. "Lateral Curvature of the Spine and Round Shoulders," p. 20.

J. JACKSON CLARKE. Amer. Jour. of Orth. Surg. vol. iv. p. 160. "A Case of Congenital Deformity of the Spine." Thirteen ribs were present, including a cervical rib, also a double lateral curve, to the left in the cervical, and to the right in the upper dorsal region; and fusion of the last cervical and first dorsal vertebræ.

KIRMISSON. Rev. d'orthopédie, Sept. 1906.

BONNAIRE. Bull. Soc. Obstét. de Paris, 1901, iv. p. 161.

CORNER and HARNETT. St. Thomas's Hosp. Rep. (1904), 1905, xxxiii. p. 190.

Spina Bifida

Spina bifida is the most common of all congenital abnormalities of the vertebral column. There is nearly always a protrusion of the

[1] *Lectures on Curvature of the Spine*, London, 1882.

contents of the vertebral canal, and the term "spina bifida" is held colloquially to include meningocele, myelocele, and syringo-myelocele.

Spina bifida is almost invariably posterior; a very rare anterior type, however, is seen occasionally, due to fission of the bodies. The posterior type is naturally always a median tumour and is frequently seen in the lumbar, sacro-lumbar, or dorso-lumbar, rarely in the dorsal, and still more rarely in the cervical region.

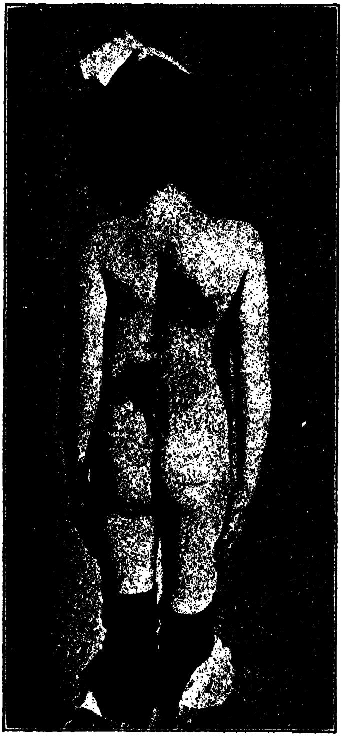


FIG. 4.—Spina bifida occulta, with Congenital Scoliosis and Abnormal Growth of Hair in the lumbar region (J. K. Sever).

A simple and unimportant form is *spina bifida occulta* (Fig. 4), often occurring low down in the spine column, and indicated by a small scar, or by a more or less rounded depression, frequently pigmented and hirsute. In these cases the laminæ have just failed to meet, and the gap has been closed with membrane sufficiently strong to resist the intra-spinal pressure. Occasionally weakness of the limbs and trophic disturbances occur later in life.

When, however, there remains a considerable gap in the posterior spinal wall, due to partial or entire arrest of bony development of the laminæ, or, still more formidable, when the stunted laminæ incline outward, then a hernia of varying size forms. Skin is sometimes found on the surface of the swelling, but more often the hernia is of a purple colour, irregular in outline, and covered with an epiblastic film of varying thickness. The integuments are thin and membranous, and likely to leak at any moment. Spina bifida varies in size and shape, from a small protrusion to an enormous dome-shaped swelling occupying much of the area of the lower part of the back. Occasionally it is globular, and sometimes more or less of a

pedicle is present. Rarely, the whole of the structures forming the posterior wall of the canal are absent, and an irregular crater exists with a minute opening at the fundus leading into the central canal of the cord.

The *appearances and signs* are well known, and a central tumour of congenital origin should always excite suspicion. We mention this because of a case which came to our notice, where a large median nævus was situated on a broad fluctuating base. A surgeon proposed to ligature the angioma, and was only prevented doing so when it was pointed out to him that he was dealing with spina bifida as well.

Of interest are the *complications*. We shall describe the various forms of talipes later. Hydrocephalus, cleft palate, ectopia vesicæ, and imperforate anus often co-exist.

Spina bifida is classified according to the structures implicated.

In (1) **Meningocele** there is merely a protrusion of the dura mater and arachnoid, but no nerves are implicated (Fig. 5). It is in this form that a pedicle is found, and, the narrow opening sometimes closing, the sac is shut off.

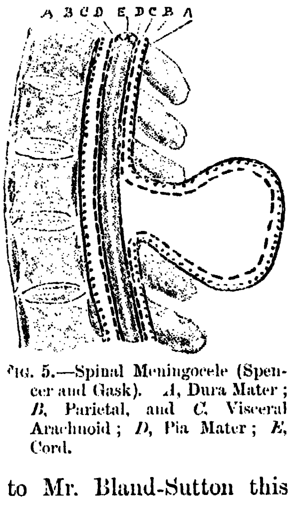


FIG. 5.—Spinal Meningocele (Spencer and Gask). *A*, Dura Mater; *B*, Parietal, and *C*, Visceral Arachnoid; *D*, Pia Mater; *E*, Cord.

2. **Myelocele.**—There is an entire failure of development at one part of the spinal column. The posterior wall is quite absent, and the medullary groove is exposed. A depression exists, red and vascular, narrowing upward into a funnel-like communication with the central canal of the cord. According to Mr. Bland-Sutton this is a common form.

3. **Meningo-myelocele** is the commonest form seen in children who survive their birth. The sac contains the non-dilated spinal cord, which is often adherent to it posteriorly, the spinal nerves which cross it, and fluid derived from the arachnoid, its wall being composed of dura mater and thin epithelium (Fig. 6).

4. **Syringo-myelocele.**—The spinal cord is distended, and forms with the membranes and nerves the wall of the cyst. It is happily a rare form (Fig. 7).

Many infants with spina bifida are either still-born or live for a

9200

few days only, and this is generally the case in meningo-myelocele and syringo-myelocele.

Prognosis.—A very considerable proportion—how great we do not know, because statistics are not available—of children born with a spina bifida do not reach puberty.[1] In the majority the tumour leaks owing to sloughing of the sac-wall, cerebro-spinal fluid escapes, septic infection of the membranes occurs, and death follows from meningitis, myelitis, or exhaustion.

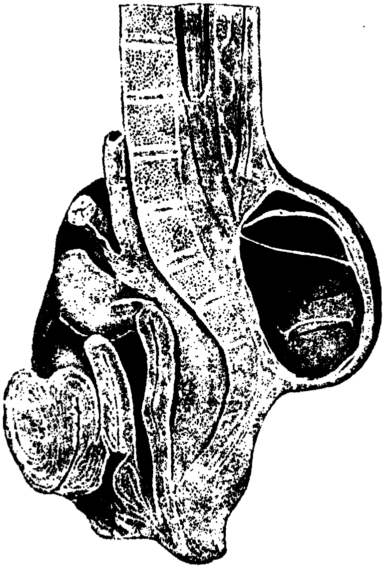


FIG. 6.—Meningo-myelocele in section (Spencer and Gask).

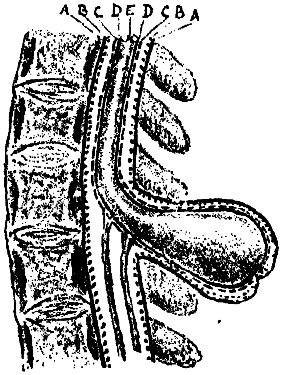


FIG. 7.—Syringo-myelocele (Spencer and Gask). *A*, Dura Mater; *B*, Parietal, and *C*, Visceral Arachnoid; *D*, Pia Mater; *E*. Cord.

In a few cases, spontaneous rupture of the sac happens with subsequent healing and shrinkage, and a cure takes place. But, whether this event comes about with or without surgical interference, in about one-half the cases death takes place at an early age from hydrocephalus, convulsions, or from the effects of the paralysis and the trophic lesions.

Still, I have seen at least seven individuals of mature years with cured spina bifida, and without any bodily deformity or mental disability. They are leading useful lives, and two of them are mothers of large families, with healthy children.

[1] Of 649 cases investigated by the committee of the Clinical Society of London 612 died in the first year.

Treatment.—Three methods are open to us:—(1) Protective and palliative; (2) Injection; (3) Operation.

Protective.—In all very large tumours with a broad base and excessively thin walls, no active interference is advisable, for it is very likely to precipitate the inevitable end. All that can be done is to protect the cyst wall by soft pads and a shield.

Injection.—Until the advent of aseptic surgery, and even after it, injection of Morton's fluid (I. gr. x., KI. gr. xxx., Glycerine ℥i.) was largely used. When contrasted with those cases where the tumour was left untouched, the results of the injection method naturally appeared encouraging, because a small proportion were cured. Often, however, the scarring and shrinking of the sac caused nerve pressure and paralysis, with talipes and other deformities. Leakage of the sac and septic meningitis occurred more often than cure.

Tapping and ligature of the sac have happily gone out of date.

The Radical Operation.[1] **Indications.**—(1) When the sac is small or of medium size, so that (2) sufficient sound integument exists on the back to be drawn together after excision of the sac, without extensive dissection. The larger the flaps required, the greater is the risk of shock and the possibility of septic infection occurring. (3) When the tumour is on the point of bursting.

Contra-Indications.—(1) Not in very large swellings; (2) If hydrocephalus exists; (3) If there is extensive involvement of nerves in the sac; (4) If other congenital abnormalities and deformities are present; (5) If thorough asepsis and good experienced nursing cannot be secured; (6) Lumbo-sacral tumours must be approached with caution, because of the difficulty of avoiding fæcal and urinary contamination.

Results of Operation.—(A) *Immediate.*—According to Lovett's [2] figures of 88 cases, 30 died from the operation, or a mortality of 34 per cent. He concludes this is nearly the usual mortality in all cases operated upon, but if groups of selected cases were dealt with, the mortality in his opinion ought to fall to 20 per cent. He himself reports 24 cases, and 9 died within three weeks of the operation, a mortality of $37\frac{1}{2}$ per cent. In private practice, of 11 cases, only 2 died. These figures do not, however, represent the

[1] Cf. Mayo Robson, *Clin. Soc. Trans.* vol. xviii. p. 339, and *Ann. Surg.*, 1895, xxii. p. 81.

[2] *Amer. Jour. Orth. Surg.* vol. v. No. 2, Oct. 1907, p. 213. Cf. also Daniel Laferte, "Spina Bifida, its Relation to Orthopedic Surgery," *Amer. Jour. Orth. Surg.* vol. vii. No. 4, May 1910, p. 469.

(B) *Subsequent Results.*—Lovett points out that within a few years there is a large secondary mortality. It is as great as the primary, and is due to hydrocephalus, convulsions, and wasting affections. So that the ultimate mortality is between 60 and 70 per cent, and Hildebrand[1] places the final cures by operation at 39 per cent.

Steps of the Operation.—Two longitudinal incisions are made over the sac on either side of the median line, and through healthy skin if possible. The incisions extend well into the skin and subcutaneous tissues above and below the tumour. The sac is then opened in a line corresponding with the skin incisions, and the fluid allowed to escape gradually. Then the sac is turned inside out, the nerves sought for and dissected out, and the spinal cord, if adherent, carefully freed. These structures are reduced into the spinal canal and the sac cut away. At the bottom of the wound is an opening, the canal of the neck of the sac. The neck is freed all round as far as possible, and as much as is convenient is cut away, the opening being closed by a purse-string suture. Flaps, usually quadrilateral, are then formed on each side, consisting of fascia, muscular, and periosteal tissue, the attached edge of the quadrilaterals being towards the middle line. They are brought together, raw surface to raw surface, leaving a ridge near the middle line. A sufficiency of redundant superficial tissue is removed, so as to allow the skin to be brought together without tension by silk-worm gut sutures. If possible, the line of closure of the skin should not be quite median; a firmer scar is obtained if it is placed laterally. Sometimes lateral incisions in the flank are required if there is great tension on the skin. Undoubtedly this adds to the risk. We lost one case owing to the edges of this accessory incision becoming septic through bad nursing. Lovett advises that two dressings should be put on, an aseptic dressing and bandages, and over these a second dressing which can be removed as it becomes soiled. The wound requires dressing every two days. Good nursing is essential, and a nurse highly trained in a Children's Hospital should have charge of the case.

CERVICAL RIBS

Owing to the serious vascular and nervous symptoms, usually appearing in middle and later life, cervical ribs are worthy of careful description.

[1] *Verhandl. d. deutsch. Ges. f. Chir.*, 1893, p. 69, and *Archiv f. klin. Chir.* Bd. xxvi.

Occurrence and Position.—According to Murphy's[1] figures, a supernumerary rib exists on both sides in 67 per cent, and on one side in 33 per cent of the cases. The supernumerary rib corresponds to the seventh cervical vertebra. Very rarely is a rib developed in addition from the sixth cervical vertebra, although the transverse process has been found much elongated.

Classification.—D. N. Eisendrath[2] abstracted all the published cases to August 1904. They were 34 in number. He described four types:—

1. The ribs are complete and articulate with the sternum.

2. A type in which the rib is usually three to four inches in length, and articulates with the first thoracic rib, or is connected with the sternum by means of a ligament.

3. A rudimentary type about one inch in length.

4. A still more rudimentary form, where the cervical rib is simply a tubercle projecting from the transverse process.

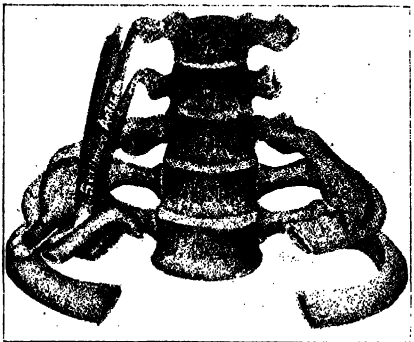


FIG. 8.—Cervical Rib present on either side (J. B. Murphy). The relationship of the Cervical Rib and Subclavian Artery are seen on the right side, and there is present a large Dilatation of the Artery. On the left side the club-shaped distal extremity of the Cervical Rib is evident.

Eisendrath regards the occurrence of a cervical rib in man as a reversion in type to some of the elementary forms. The cervical rib exists in reptiles. He regards it as an abnormal development of the anterior ossific nucleus of the transverse process of the seventh cervical vertebra, but on this point we shall have to speak at some length.

Grüber[3] classifies as follows:—

1. A process-like projection extending scarcely beyond the transverse process.

2. A supernumerary rib not more than one inch in length, with a free end or attached to the first rib.

3. A thin rib extending to the anterior border of the scalenus anticus with a free or attached end.

[1] *Annals of Surg.* vol. xli. p. 401. [2] *Amer. Med.*, 20th August 1904.
[3] Quoted by Murphy, *Ann. Surg.* vol. xli. p. 401.

4. A complete rib, with a sterno-costal cartilage or a broad end joining it to the sternum or to the first rib.

Development.—In 29 cases the average age when attention was drawn to the condition was 27 years. We must not infer from this, as Murphy does, that "a cervical rib does not appear to develop until the patient is well into adult life." I operated last year on a child aged 2 years. Doubtless these ribs exist in early life, but rarely give rise to symptoms, and therefore escape notice.

It is striking to observe that, unlike normal ribs, the longer the supernumerary rib grows, and therefore the greater the distance from the spine, the broader it becomes; and sometimes its distal end forms a definite bony tumour in the posterior triangle. In respect to its broad peripheral extremity, the abnormal rib resembles a cervical transverse process. The question therefore arises, is it merely an elongated transverse process, or is it a separate structure of independent development? The latter is no doubt correct. Very often, as in Case 1, p. 26, there is a distinct articulation of the central end of the structure to the spinal column. Then, too, the scalenus anticus, usually, and sometimes the scalenus medius are inserted into the cervical rib and at a distance from the spine, thus affording a parallel with the normal attachment of those muscles.

As to the actual method of elongation, is it by the growth of bone from the primary ossific centre near the vertebræ, or is it by the activity of the cartilage covering the tip? The distance from the spine of the attachment of the scaleni to the rib, and the peculiar broad distal end of the rib, seem to point to the latter hypothesis.

Effects.—These will be more fully discussed when we deal with symptoms. Briefly, they are arterial and nervous, very rarely venous. Murphy remarks on the rarity of œdema of the upper extremity, and concludes quite rightly that the vein is seldom compressed. The explanation is found in the dispositions of the parts. The rib develops behind and beneath the branches of the brachial plexus, or else it is found lying between the cords. In either case it carries forward the subclavian artery, and compresses it, together with some or all of the nerve cords, against the external and posterior border of the scalenus anticus, but not against the normal first rib. As the vein lies in front of that muscle it is out of the way, and is not therefore subjected to pressure. (Fig. 9.)

The effects on the artery are:—

(*a*) Narrowing and partial obstruction of the blood stream, particularly when the arm is hanging at the side, but relieved by raising the arm above the head.

(*b*) Endarteritis and thrombosis.

(*c*) Aneurismal dilatation.

(*d*) Gangrene.

The effects on the nerves are :—hyperæsthesia, anæsthesia, weakness and paresis, motor paralysis and atrophy of muscles. The orbital and pupillary fibres of the anterior nerve roots escape.

If, as occurred in a case of mine, the scalenus anticus divides below, one part being inserted into the cervical rib, and the other into the first rib, destructive pressure upon the artery and nerves is inevitable as the abnormal bone grows forward and downward, and the artery and nerves are nipped between the unyielding cervical rib behind and the posterior and outer edge of the scalenus anticus in front.

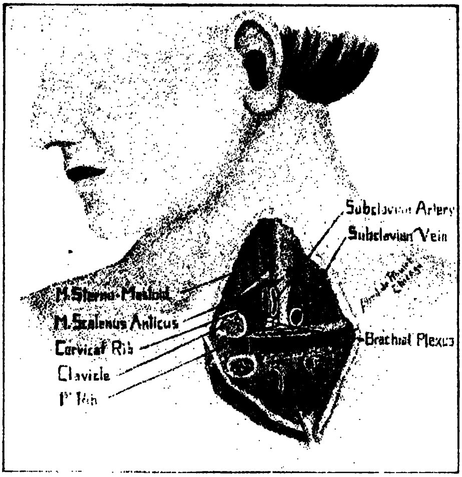


FIG. 9.—A Dissection of the parts involved by the presence of a Cervical Rib. The Subclavian Artery is flattened between the Scalenus Anticus and the Cervical Rib. The calibre of the Subclavian Vein is not altered (J. B. Murphy).

Symptoms may be discussed under three headings—(*a*) of nerve origin, (*b*) of vascular origin, (*c*) presence of a tumour of bone-like character in the posterior triangle.

Nerve Symptoms.—In the early stages of pressure tingling and numbness in the arm and forearm are felt, more particularly in the area supplied by the ulnar nerve and the little finger. Later, boring pains and muscular weakness follow, to be succeeded by anæsthesia, paralysis, and atrophy of muscles. The writer remembers a case he saw twenty-three years ago when undergoing the ordeal of examination. A man, aged 45 years, complained of tingling and numbness in the little finger of the right hand, and there was an

herpetic eruption on the finger. On feeling above the clavicle, an elongated bony mass was felt, which proved to be a cervical rib. The earlier nerve symptoms are relieved by raising the arm above the head, elevating the shoulders, or supporting the shoulder girdle by resting on the elbows. It is more comfortable for the patient to sleep at night with the arms above the head than in the usual positions.

Vascular Symptoms.—We have already indicated that the vein escapes, so that the limb does not become congested or œdematous. On the contrary it is blanched and cold, especially during muscular exertion, and the skin may be wrinkled. The brachial and radial pulses are diminished, disappear when the limb is hanging down, and reappear if the arm is held above the head.[1] In a case which recently came under our notice, impending gangrene was warded off by fixing the patient's arm in the latter position.

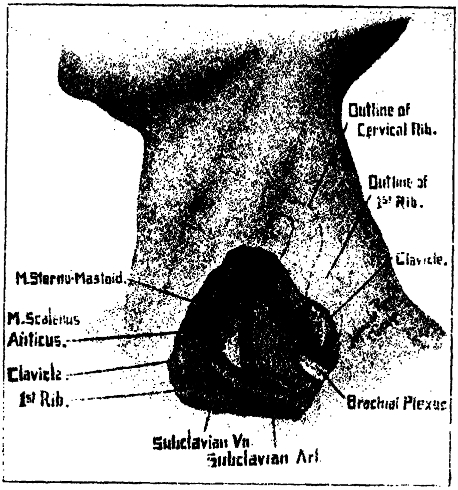


FIG. 10.—Cervical Rib with Aneurism of the Third Part of the Subclavian Artery. Note the relationships of the Cervical Rib, the Artery, and the Vein to the Scalenus Anticus Muscle (J. B. Murphy).

Where the artery passes across the broad end of the cervical rib, it is frequently flattened out, and simulates an aneurism, and both antero-posterior and lateral pulsation are in evidence. Sometimes an aneurism forms (Fig. 10), but it is difficult to diagnose it with certainty before operation. Its presence can only be verified by dissection. In Case 1, below the point of obstruction the artery was dilated in a fusiform manner to twice the normal calibre. After removal of the rib, and before the closure of the wound, I had the satisfaction of observing the dilatation disappear, so that the normal diameter at the affected spot was regained. Despite

[1] In some cases, and in one of my own, the radial pulsation did not return after removal of the offending piece of bone.

this remarkable change, pulsation had not reappeared in the corresponding radial vessel three weeks after the operation. As a result of the abnormal pressure on the vessel an endarteritis is set up. In some cases it is of the obliterating type, and then gangrene of the arm follows. In other cases the onset of endarteritis precedes the formation of aneurism, but as to the exact *rôles* played by inflammatory changes in the arterial walls and trauma upon the vessel in the production of aneurism, we have not sufficient data to determine. In some cases we may surmise that thrombosis precedes softening and aneurism, and eventually results in gangrene. In other cases rapid thrombosis may be due to direct injury of the vessel.

Tumour-formation.—Just above the clavicle in children, and in the delicate necks of thin young women, an elongated bony mass may be felt in the posterior triangle, and over it the artery can be felt beating.[1] In older people, when the distal end of the cervical rib has broadened, a mass like an exostosis is palpable, occupying the whole of the subclavian triangle.

Radiographic Examination.—If, as is not often the case, there is any doubt, a skiagram (Plates III. and IV.) should be taken; careful note being made of the position of the patient and the tube, and the angle at which the rays are focused on the rib. Very distorted shadows are readily produced, and they are often blurred in the dark shade of the adjacent vertebræ. In children the shadow of the cervical rib stands out as a clear, well-defined, nearly vertical band. In adults the appearances are sometimes confused.

Association of Cervical Ribs with Defects of the Vertebræ and Congenital Scoliosis.—A case of scoliosis which came under the author's notice drew his attention to this point. He discovered a cervical rib on the left side and a wedge-shaped sixth cervical vertebra. A good deal of work has been done on this subject, and it requires separate notice (p. 29).

Diagnosis.—Unless attention is drawn to the part either by symptoms in the arm, or by the history of congenital scoliosis, the existence of a supernumerary rib escapes attention. But when once it is suspected, then the diagnosis can easily be verified. Care should be taken not to assume too readily the presence of an aneurism, for a flattened-out subclavian artery is very deceptive.

Prognosis.—So long as symptoms do not arise, the condition is

[1] I have, however, felt pulsation in this portion, which proved to be due to the transversalis colli and not the subclavian artery.

one which need not cause anxiety, but when once pressure signs appear, then the integrity of the limb is endangered.

Treatment.—Nothing avails except removal of the cause of pressure. It is not always necessary to remove the whole rib, but only the compressing part. Still, it is essential to take away the periosteum with the bone, to prevent re-formation of bone and recurrence of symptoms. Whenever it is possible and safe to do so, the writer removes the whole rib. As large a piece as is convenient is excised with saw or forceps, and the remainder is nibbled away with Hoffman's forceps. Considerable care is required, as the spinal column is approached, and the risk of injury to the sympathetic must be borne in mind.

Some writers speak of the operation as an easy one. It may be so in isolated cases, but if the ribs pass through the cords of the plexus, if the cords are flattened out by it, if the artery is dilated and softened, or if an aneurism is present, then the operation often presents grave difficulties.

CASE 1.—*Left Cervical Rib; Impending Gangrene; Operation; Relief.*—Ellen S., aged 36 years, was brought under the writer's notice on 12th December 1908, by his colleague, Dr. Hebb, at Westminster Hospital. She was admitted on account of pain in the left arm and tingling in the elbow, coldness and numbness of the hand. Dr. Hebb saw her shortly after admission, and discovered a cervical rib. As he feared impending gangrene, he directed that the arm should be held above the head. The radial pulse on admission was absent, and the hand cold. The effect of the change of position was to diminish the blanching of the hand, but the radial pulse did not reappear. A skiagram was taken, and an elongated bony mass, which could be felt in the posterior triangle, was identified as a cervical rib. No abnormal vascular expansion was felt above the clavicle.

Operation.—An incision $4\frac{1}{2}$ inches in length was made over the clavicle, and from the inner end the incision was carried up the posterior border of the sterno-mastoid muscle for $2\frac{1}{2}$ inches. The flap was then reflected and the subclavian triangle exposed. After defining the omohyoid muscle and the cords of the brachial plexus which lay external to the cervical rib, a broad fusiform *non-pulsating* structure was seen lying vertically in the triangle, and bounded above by an acute angle formed by the posterior edge of the scalenus anticus and the cervical rib. The non-pulsatile dilated structure was identified as the subclavian artery, and it was so firm and resistant that it was thought to be thrombosed.

The artery was displaced inward, and one inch of the rib was removed with its periosteum; then the remainder of the rib was removed, centrally by biting it away with Hoffman's forceps, and distally with a chisel.

The pulsation in the artery recommenced, not when the rib was

removed, but when the sharp external edge of the scalenus was divided. Therefore the cause of compression of the artery was the close approximation of the cervical rib to the posterior edge of the scalenus anticus, and it was clearly shown, by observing the effect of moving the upper extremity, that the approximation of these structures was closer when the arm was lying at the side than when elevated. It is worthy of remark that the dilatation of the artery was below the constriction, and not above it, as if softening had taken place in its wall from injury. After the division of the scalenus anticus fibres and resumption of pulsation, the dilated portion of the artery commenced to contract from above downward, and the vessel resumed its normal calibre. The clavicle was divided, so as to trace the extent of the dilatation of the vessel, and it

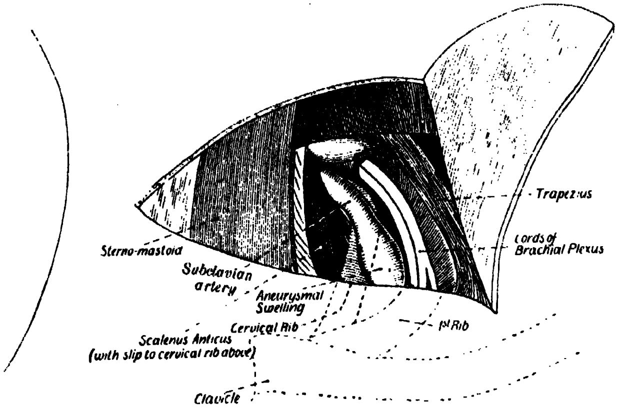


FIG. 11.—To illustrate Case 1. A Fusiform Swelling is present on the Subclavian Artery *below* the point where it had been compressed between the scalenus anticus and the cervical rib. From a drawing made by my friend and colleague, Mr. E. Rock Carling, at the time of operation.

was found to extend half an inch below it. This bone was wired and the wound was closed.

For the accompanying sketch of the parts (Fig. 11) I am indebted to my friend and colleague, Mr. E. Rock Carling, who assisted me at the operation.

Gradually the sensation and power returned to the limb, but the radial pulse had not reappeared when the patient left the hospital three weeks after the operation.

CASE 2.—*Cervical Rib: Congenital Scoliosis; Operation.*—Nellie A., aged 5½ years, was admitted to Westminster Hospital on 9th January 1909, under the care of Dr. Hebb, for a cough and pain in the axilla. She had a suppurating middle finger on the right hand, and Dr. Hebb discovered that there was a cervical rib on that side. It was further noted that cervico-dorsal scoliosis, convex to the left side,

existed. In the right subclavian triangle a hard bony lump could be felt running from the vertebral column downward and outward to within a quarter of an inch of the clavicle, and behind this bone the mass seemed to end in a rounded extremity. No pressure symptoms were present, and the radial pulse was good and equal to that on the opposite side. A pulsating vessel crossed the bony mass in the posterior triangle. It proved to be the transversalis colli artery.

Operation.—Performed on 15th June 1909 by the writer. A triangular flap of skin was reflected, the apex of the triangle being situated at the junction of the posterior border of the sterno-mastoid and the clavicle. The subclavian triangle was exposed, after identification of

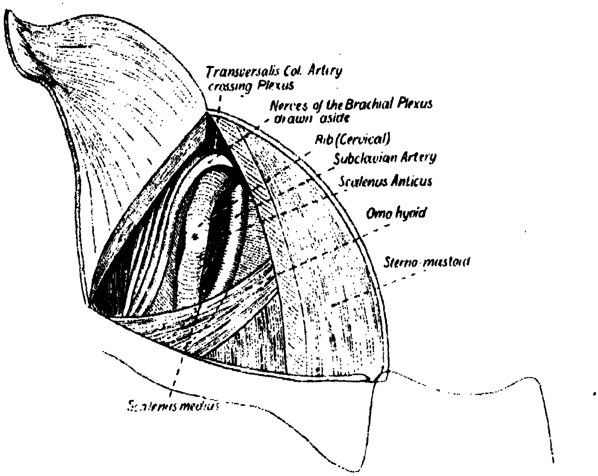


FIG. 12.—To illustrate Case 2. The Cervical Rib is *in situ*, and the * indicates the point where it was subsequently divided. The lowest cord of the brachial plexus is stretched tightly around the cervical rib, and the subclavian artery appears in the angle formed by the scalenus anticus muscle and the cervical rib. From a drawing made by my friend and colleague, Mr. E. Rock Carling, at the time of operation.

the omohyoid muscle and the transversalis colli artery, which ran nearly parallel to the muscle. On deeper dissection the abnormal rib was found almost entirely concealed by the brachial plexus, the lowest cord of which was stretched sharply round the inner edge of the cervical rib. The subclavian artery ran parallel with the inner border of the rib for a considerable distance, and then turned sharply out across it. The rib was divided at its most superficial part (* in Fig. 12), and the two portions removed piecemeal. In all about one inch was excised. After this the subclavian artery expanded to almost double its previous diameter.

The recovery was entirely uneventful. For the sketch of the parts I am again indebted to Mr. E. Rock Carling.

Some Recent References to Cervical Ribs

Keen. Amer. Journ. Med. Sci., Feb. 1907, gives a review of 42 operations.
Murphy, J. B. Surg. Gyn. and Obst., Oct. 1906.
Szokol. Chirurgie (Russian), 1907, S. 23; also Abst. Zentralbl. f. Chir. und mech. Orth.
Russel, C. K. Med. Rec., Feb. 16, 1907.
Farr, C. B. Amer. Med., May 1907.
Broadbent, W. Brit. Med. Jour., May 5, 1906.
Von Rutkowski. Zeitschr. f. klin. Med. Bd. lx. Nos. 3 and 4.
Spiller and Gittings. N.Y. Med. Jour., Oct. 6, 1906.

Cervical Ribs, Congenital Defects of the Spine, and Congenital Scoliosis

Radiographic examination of cases of cervical ribs has led to the recognition of the important fact that defects of the spine, of congenital origin, frequently co-exist. We have also learnt that some intractable cases of scoliosis are due to congenital abnormalities of the vertebral column.

This subject has been treated by Drehmann [1] and by Krause.[2] Drehmann remarks that when cervical ribs are present other deformities are frequently found. He instances supernumerary rudimentary vertebræ, cleavage of the vertebræ, with absence of the spinous processes, apparent union of ribs, and absence of a portion of a rib or ribs. The cases in question may be divided into two groups with transitional forms.

Group I. comprises those cases where, in addition to a cervical rib, there is an associated rudimentary vertebra with a scoliotic cervico-dorsal curve, convex on the side of the cervical rib.

Group II. includes those cases in which there is a cervical rib without a rudimentary vertebra, and in them Drehmann found other congenital anomalies.

In the transitional cases there are imperfect or nearly complete cervical ribs with a rudimentary wedge-shaped vertebra, the base of it being toward the cervical rib.

Krause, writing on the subject, says:—"Among a large number of scoliotic patients, cases are occasionally found which are characterised by a peculiarly high location of the curve, which

[1] *Zeitschr. f. orth. Chir.* Bd. xvi. Hefte 1 and 2.
[2] *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Bd. x. Heft 6.
Both these articles are abstracted in the *Amer. Jour. Orth. Surg.*, July 1907, pp. 120-121, from which the above remarks are taken.

is very rigid and limited to but few vertebræ. In such cases a cervical rib is not uncommon. However, this is not the most usual condition. More often these cases present complicated developmental anomalies of the ribs and vertebræ, *e.g.* supernumerary rudimentary vertebræ at the junction of the cervical and dorsal segments. There also occur fusion and bony union between neighbouring vertebræ, as well as failure of bony union between the laminæ of a vertebral arch, or cleavage of the vertebral arch and body (spina bifida of slight degree without evidence of change in the coverings of the cord).

"As regards the anomalies of the ribs, there are seen most often, in addition to the relatively uncommon cervical ribs, supernumerary ribs, which arise from the above-mentioned wedge-shaped rudimentary vertebræ, and these too are most frequently found inserted between the first and last dorsal vertebræ. Sometimes, ribs are found arising from a common point, and continue to be fused for some distance. In other cases the normal course of the rib suddenly ceases and is continued in cartilage.

"Finally, there are cases of congenital cervico-dorsal scoliosis, without any of the above-mentioned vertebral or costal anomalies." Heredity appears to play a distinct part in these deformities.

We have thus dwelt on this matter at some length because of the interest awakened by the investigations into the anatomy of congenital scoliosis.

Congenital Deficiency of the Clavicle

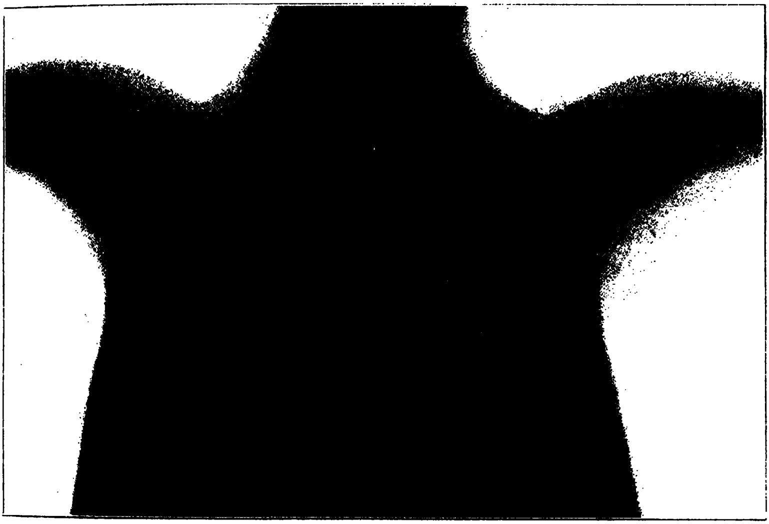
Synonyms—Cleido-cranial dysostosis; Congenital osteodysplasia of the clavicles, cranial bones, and teeth.

Partial absence of the clavicles is a condition seldom met with,[1] and is of little importance from a therapeutic point of view, since —strange to say—very slight disability results.[2] But, as it is usually associated with certain marked peculiarities of the cranial bones and teeth, indicating some abnormality of early development, its study becomes of interest, especially as to the relation of this

[1] The literature on the subject embraces references to about 40 cases, and complete absence of the clavicle is only three times stated to have existed.

[2] Walsham, in reporting a case, pointed out that the freedom from disability shows that the importance of non-union of the clavicle after fracture has been much exaggerated, a deduction of value from a medico-legal point of view.—*B.M.J.* vol. ii., 1888, p. 994. Here too is given a bibliography.

PLATE V.



Radiogram of a boy, aged 3 years, with Congenital Deficiency of the Acromial end of the Clavicle on the right side, and a Rudimentary Clavicle on the left side (H. M. Sherman).

To face page 30.

malformation to such conditions as achondroplasia fœtalis. It is out of place here to give more than an outline of these interesting cases, and the following details, coupled with bibliographical notes, must suffice.

The symptoms of the clavicular condition are so slight that, as a rule, the detection[1] has been accidental, unless the observer's suspicions have been awakened by the associated cranial peculiarities;

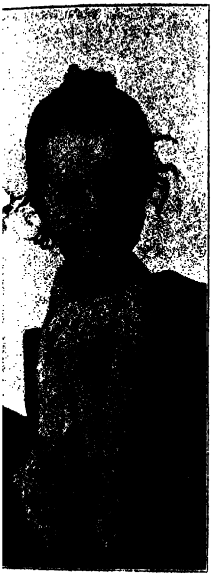


FIG. 13.

ssive Approximation of the Shoulders in Congenital Deficiency of the Clavicle. Cf. Radiogram, Plate V. (H. M. Sherman).

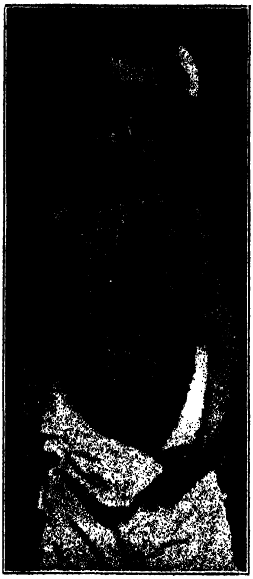


FIG. 14.

FIG. 15.

Congenital Deficiency of both Clavicles.

Fig. 14, the usual appearance of the girl. Fig. 15, the shoulders are passively approximated.

or, as in Dr. G. A. Carpenter's case,[2] the abnormality having been recognised in one member of a family, careful search among the relatives has brought other cases to light.

In partial deficiency of the clavicles the shoulders droop slightly and fall forward a little, and the vertebral borders of the scapulæ project. The shoulders can be actively approximated anteriorly, and by the use of slight force dragged still farther forward until

[1] Doubtless, as the condition becomes more widely known many more cases will be recognised.

[2] *Lancet*, 7th January 1899.

FIG. 16.—Schorstein's Case of Congenital Absence of the Clavicles.

FIG. 17.—G. A. Carpenter's Case of Congenital Absence of the Clavicles.

Fig. 18.—G. A. Carpenter's Case of Congenital Absence of the Clavicles. The effect of raising the arms upon the position of the scapulæ is very striking.

Fig. 19.—G. A. Carpenter's Case of Congenital Absence of the Clavicles. The upper limbs can be completely crossed behind the neck.

in actual contact, if not prevented by too much fat on the front of the thorax. Practically all movements, even to considerable weight lifting, are normal. On palpation, and by means of radiography, absence more or less of the middle portion of the clavicle is noted, the sternal end being nearly always present, and the acromial end less constantly fully developed[1] (Plates V. and VI.). The patient's height is deficient,[2] and the loss of stature is often further increased by kypho-scoliosis.[3] The head is relatively large; the cranium is broad,[4] flat-topped, with prominent parietal and frontal eminences, separated by grooves or sulci in the positions of the sutures, including the frontal. The forehead, therefore,

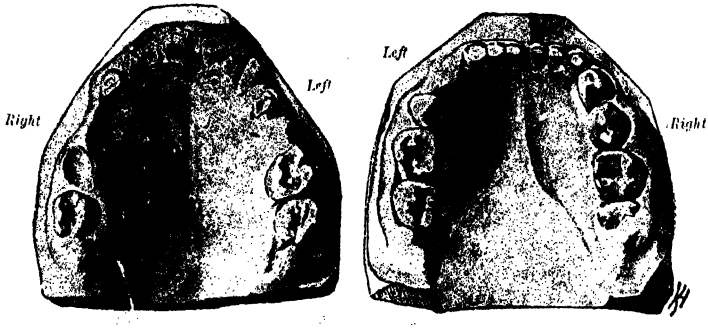


FIG. 20.—Casts of the Upper and Lower Jaws from a patient aged 18½ years, the subject of Congenital Deficiency of the Clavicles. Note the persistence of the milk teeth (Klar).

presents lateral bosses, separated by a deep vertical groove passing upwards from the root of the nose. Depressions are particularly well marked at the sites of the anterior[5] and posterior fontanelles, which are either found to be unossified, or close very late in life. The condition is that of imperfect development of

[1] For illustrations see *Trans. Amer. Orth. Ass.* vol. xv. p. 388; *Lancet*, 1899, vol. i. p. 12.

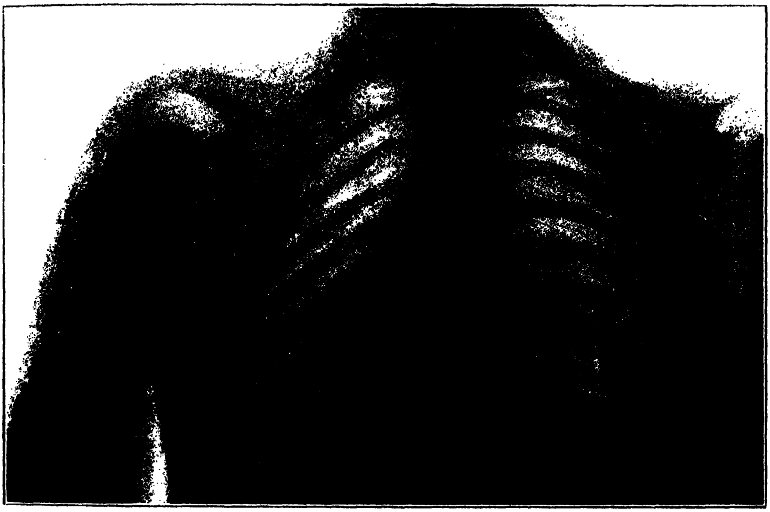
[2] Schörstein's case, aged 13 years, was 4 ft. 2 in. in height. Klar's case, aged 18½ years, was 4 ft. 5 in.; a man aged 36, according to Gegenbauer, was just under 5 ft.

[3] This was present in 25 per cent of the cases. It was also found in an anencephalic monster, in which the left clavicle was rudimentary (Scheuthauer).

[4] In one of Marie's cases the transverse diameter was 174 millimetres, as against the average of 159·6 millimetres.

[5] The anterior fontanelle was found open in patients aged 39 and 47 years (Marie), and in a patient aged 54 (Gianettasio).

PLATE VI.



Radiogram of a girl, aged 7 years, with complete Absence of both Clavicles (H. M. Sherman).

To face page 34.

the frontal[1] and of the vertical plate of the occipital, and Schörstein adds possibly of the nasal bones. The palate is usually high and perhaps cleft, as in two of Marie's cases. The permanent teeth are absent or defective, irregular and decayed. Radiography demonstrated the presence of the germs only of the permanent teeth in Klar's case, aged $18\frac{1}{2}$ years. The milk teeth are late in appearing, and often persist for a long time (Figs. 20 and 21).

Fig. 21.—Casts of the Jaws in Fig. 20 placed in apposition (Klar).

The condition is markedly hereditary. It was found in parents or brothers or sisters (Marie, Sherman, Carpenter, and Gegenbauer). Marie states that it is never known to affect more than two generations.[2] The deformity is transmitted through both male and female sides, and the sufferers frequently develop rickets in infancy (Sherman, Klar, Schorstein, Walsham, Bussche).[3] The mental condition is apparently fair in most cases. In Kappeter's case it was feeble, and Dowse's patient developed epilepsy. Other deformities are sometimes present in the family. Congenital varus has been frequently observed. Considering the rarity of the affection and the frequency of club-foot, it is remarkable that a history of the latter defect, either in the patient or in some relative, is seldom elicited.

Pathology and Ætiology.—Whatever the causation may be, it is obvious that the abnormality must be traced to a very early period of intra-uterine life. The clavicle is the first bone to show an ossifying centre, which appears about the seventh week. The other bones affected also ossify early and develop in membrane. It is not definitely known how the entire clavicle develops. Possibly the central portion is not laid down in cartilage at all, but originates in membrane. There is considerable evidence in favour of this—a point, however, which cannot be discussed

[1] Not only may the frontal suture remain open, but, as in one of Marie's cases, there may be a medio-frontal fontanelle or fontanelle metopica. Hence perhaps arose the legend of the Cyclops.

[2] Possibly in Dr. G. A. Carpenter's case three generations were involved: grandmother, father, and children, but the case of the grandmother is very uncertain.

[3] For illustrations of the teeth see Klar's pictures (*Zeitschr. f. orth. Chir.* Bd. xv., 1906, 2 bis 4 Hefte, p. 424).

here. This possibility simplifies matters, but does not take us very far.

A large number of hypotheses have been hazarded, such as reversion to an aclavicular prehensile type, want of room in the amniotic cavity, and chondrodystrophia fœtalis. The last two require little consideration. Views as to the part played by the amnion will be found discussed in the section dealing with supernumerary fingers (p. 103) and club-foot (p. 225).

Chondrodystrophia fœtalis is an affection arising at a later date than osteodysplasia congenita, and in the former no sign of any clavicular deficiency exists, but rather the reverse.

Bibliography

T. S. Dowse. Path. Soc. Trans., vol. xxvi., 1875, 166.

Schorstein. Lancet, 7th January 1899.

Carpenter. Lancet, 7th January 1899.

Walsham. B.M.J., 1888, vol. ii. p. 994.

Sherman. Trans. Am. Orth. Ass., vol. xv., 1902.

Max. M. Klar. Zeitschr. f. orth. Chir., Band xv., 1906, 2 bis 4 Hefte, p. 424.

Martin. Jour. de méd. et chir., etc., S. xxiii. 456, Paris.

F. Stahmann. Zeitschr. f. med. Chir. u. Geburtshilfe, Magdeburg und Leipsic, 1857, Band ii. 433.

Gegenbauer. Jena'sche Zeitschr. f. Med. u. Naturwissenschaft, Leipsic, 1864, p. 1 *et seq.*

Niemeyer. Bericht über die xl. Versammlung deutscher Naturförscher u. Ärzte, Hanover, 1866, p. 236.

Scheuthauer. Wien. med. Zeit., 1871, p. 293.

Kappeler. Arch. d. Heilk., 1875, Band xvi. p. 265.

Guzzoni, degli Aucarani. Bulletino scientifico, anno 9, p. 72, Pavia, 1887.

Bussche. Inaug. Dissert., Freiburg, 1890, Amsterdam, 1890.

Pierre Marie et Paul Sainton. Sur la dysostose cleido-cranienne héréditaire. Rev. neurologique, 1898, vol. vi.

Pierre. De la dysostose cleido-cranienne héréditaire. Thèse, Paris, 1898.

Gianettasio. Assenza congenita delle clavicole.

Sachs. Über angeborene Defekte des Schlüsselblattes. Inaug. Dissert., Leipsic, 1902.

Grosz. Münch. med. Wochenschr., 1903, No. xxvii.

Preleitner. Wien. klin. Wochenschr., 1903, No. iii.

Duncan, C. L. Fitzwilliam. Lancet, 19th Nov. 1910, with full bibliography.

Absence of the Pectoral Muscles

In some instances the pectoralis major alone is absent, in others both the major and minor. In the latter the anterior fold of the axilla is thin and membranous, and the patient is unable to bring the arm across the chest.

ABNORMALITIES OF THE RIBS

The ribs, in number, may exceed the normal, or be less. They may also be partially defective either in bone or cartilage, or they may be fused.

As examples of excess, we refer to cervical ribs, and to those cases where a supernumerary dorsal vertebra carries with it an additional rib. In practice we find that congenital scoliosis, Sprengel's shoulder, and deficiency of the clavicle, are often associated with anomalies of the ribs. Thus a little girl, aged 10 years, with double Sprengel's shoulder, whom I saw, had 13 ribs on the right side, and

FIG. 22.—Congenital Funnel-shaped deformity of the Chest (after Rédard).

a wedge-shaped vertebra between the second and third dorsal. She also had marked congenital spinal curvature. When some of the dorsal vertebræ are suppressed, the number of ribs is less than normal. Suppression of an entire rib is uncommon, but a case is recorded in which the twelfth rib was entirely undeveloped. The surgeon, not having counted the ribs, proceeded with a kidney operation, and relying upon the normal landmark, the tip of the last rib, opened the pleura.

Partial deficiency of either the bone or cartilage of the ribs is very commonly associated with congenital defects of the spine and shoulder girdle. In such cases the intercostal muscles, or portions of them, are absent. We have met with absence of the anterior halves of the left ninth and tenth ribs in a case of congenital scoliosis and a very long cervical rib on that side.

Fusion of the ribs is seen when the number is in excess of the normal.

FUNNEL-CHEST

Synonym—Pectus excavatum.

This deformity is usually congenital, although it is likely to be

FIG. 23.—Congenital Depression of the Sternum, from a girl aged 12 years.

aggravated by adenoids or nasal obstructions, or by rickety softening of bones.

In the less marked degrees there are depressions in the gladiolus, rarely in the manubrium. In the worst form the whole sternum is depressed, and the lateral diameter of the chest is increased (Figs. 22 and 23).

No treatment except removal of the nasal and post-nasal obstruction, and breathing exercises, has any effect.

Congenital Elevation of the Scapula, or Sprengel's Shoulder

This is a somewhat rare condition.[1] Zesas[2] in 1904 collected more than a hundred cases; Horwitz[3] summarises 120 reported cases, and adds 16 unpublished cases. If the deformity were better known, it is probable that this number would be exceeded, especially as the asymmetry of the shoulders and the associated deviation of the spine often cause the exact nature of the cases to be overlooked. The observations of Eulenburg,[4] Willett and Walsham,[5] McBurney and Sands[6] excited little attention; so that when Sprengel[7] in 1891 described four cases, his name became associated with the deformity, which is now generally known as Sprengel's shoulder. At the present time the bibliography is extensive, and the writer refers the reader to a complete list at the end of this article taken from Horwitz's paper in the *American Journal of Orthopedic Surgery*, vol. vi. No. 2, p. 260 *et seq.*

Symptoms.—The symptoms are an abnormally high position of the scapula, a difference of 12 centimetres being noticed in Fröhlich's case, leading to obvious asymmetry of the shoulders. In 9 per cent of the cases recorded both scapulæ were elevated. Usually more or less rotation of the bones is present about the antero-posterior axis, so that the vertebral border is no longer parallel to the line of the spinous processes, but is inclined in such a way that the upper angle is nearer the mid line than the lower. The rotation, however, may be in the reverse direction.[8] The

[1] Not so rare as Sir J. Hutchinson states, *Polyclinic Jour.*, Sept. 1901, p. 126. A case described in this article is spoken of as the first typical example recognised in England.

[2] *Zeitschr. f. orth. Chir.* Bd. xv. Heft 1.

[3] *Amer. Jour. Orth. Surg.* vol. vi. No. 2, p. 260.

[4] *Arch. f. klin. Chir.* Bd. iv., 1868; quoted by D. G. Zesas, "Über den angeborenen Hochstand des Schulterblattes," *Zeitschr. f. orth. Chir.* Bd. xv. Heft 1, 1905.

[5] *Trans. Roy. Med. and Chir. Soc.*, 1880-1883.

[6] *N. Y. Med. Jour.*, 1888, p. 582.

[7] "Die angeborene Verschiebung des Schulterblattes nach oben," *Arch. f. klin. Chir.* Bd. xlii. S. 3, 545-549, 1891; and *Centralb. f. Chir.*, 1893.

[8] Whitman and Bradford and Lovett say that the lower angle is nearer the spine, yet the illustrations in their work show the reverse, and this is particularly noticeable in Bradford and Lovett's work, *Orthopedic Surgery*, p. 390. In Gibney's case (*Trans. Amer. Orthop. Assoc.*, 1901, p. 308) the lower angle is described as overlapping the spine. In this patient, however, there was a history of fracture of the clavicle when she was eighteen months old.

clavicle is usually shortened,[1] and H. A. Steele[2] states that the difference is as much as one inch, so that the scapula and the

FIG. 24.—Anterior view of a girl, aged 7 years, with Congenital Elevation of the Left Shoulder. This case is described by Augustus Wilson and J. Torrance Rugh as "A case of Anomalous Spinous Process of the Seventh Cervical Vertebra Articulating with the Scapula" (*Ann. Surg.* vol. xxxi. p. 468 *et seq.*).

shoulder are nearer to the spine, as though the shoulder girdle had become shortened on the affected side. The upper angle of the

[1] Tridon, *Rev. d'orthop.*, Jan. 1905, p. 71.
[2] *Trans. Amer. Orthop. Assoc.* vol. xv., 1902, p. 18.

scapula is unduly prominent in the neck.[1] The range of mobility is lessened,[2] elevation of the arm being especially interfered with.[3]

FIG. 25.—Posterior view of the case in Fig. 24. The Elevation of the Left Scapula, its Abnormal Shape and Outline, are seen (Augustus Wilson and J. Torrance Rugh).

The disability at first may be slight, but it is more evident about

[1] So that Kölliker (*Arch. f. klin. Chir.*, 1891, Bd. xlii. S. 9, 25; and *Centralbl. f. Chir.*, 1895, No. xxvii.) diagnosed the prominent angle of the scapula in the neck as an exostosis.

[2] Freiberg, *Annals of Surg.*, May 1899.

[3] Or, rather abduction and elevation, and this is an important point, as it serves to differentiate the condition from inequality of the shoulders due to scoliosis.

puberty, a point noticed by Weiss and Fröhlich,[1] when manual work is often commenced. It is evident, therefore, that disability becomes greater rather than less as time goes on. The upper part of the chest

FIG. 26.—The Positions assumed by the Shoulders on Extension of the Arms in case, Figs. 24 and 25 (H. Augustus Wilson and J. Torrance Rugh).

is often badly developed and narrow in its transverse diameter, and in bilateral cases the dorsal and lower cervical vertebræ are prominent; in unilateral cases the spines are often deviated from the affected side, although the deviation is occasionally in the

[1] *Rev. méd. de l'Est*, June 1, 1902.

opposite direction. Torticollis has been noticed on the deformed side in 14 cases, and facial asymmetry in 20 cases.

In unilateral cases the patient presents an asymmetrical appear-

FIG. 27.—The Improvement in the Movements of the Left Upper Extremity, after operation on case, Figs. 24 and 25 (H. Angustus Wilson and J. Torrance Rugh).

ance, one shoulder being high, and the head drawn to the side of the deformity.

The affection has been observed on the right side 49 times, and on the left 69, and has been noted to be bilateral 14 times. Both sexes are equally affected, and there is one

case reported by Sick where several members of one family were deformed in this way.

FIG. 28.—Posterior View of H. Augustus Wilson's and J. Torrance Rugh's case of a girl, aged 16 years, described as "Anomalous Process of Seventh Cervical Vertebra articulating with the Scapula." The left shoulder is elevated and the left scapula is high.

Pathology.—Horwitz[1] states that the scapular index is expressed as follows:—

$$\frac{100 \times \text{breadth}}{\text{length}}$$

[1] *Loc. sup. cit.*

In Europeans this index is according to Broca 65·91, and according to Flower and Garson 65·2.

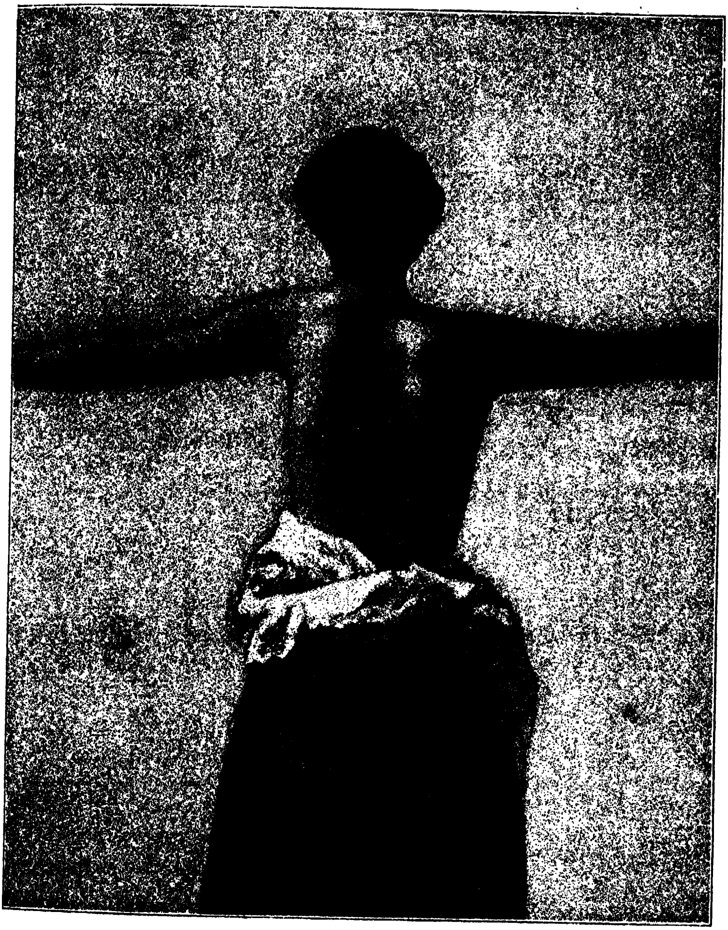


FIG. 29.—The same patient as in Fig. 28, with the Arms Extended.

The affected scapula differs from the normal in

(a) The changed relation of the scapular diameters to each other.

(b) The curving of the superior border or bending forward of the supraspinous portion.

(c) The prolongation or rounding of the superior median angle.

(*d*) The presence of exostoses or bony plates and articulations with the vertebral column.

(*a*) Diameters.—In Horwitz's tables the change in the relation of the diameters exists in 53 cases, or 39 per cent. These alterations consist of a diminution in the vertical diameter or an increase in the horizontal, the reverse not being observed.

(*b*) Curving of the superior border or bending forward of the supraspinous portion.—This was seen in 25 cases, or 18·5 per cent, and is due in all probability not to pressure exerted *in utero*, but is part of the phenomena of the failure of descent. The scapula originates in the cervical region, and failing to descend, the supraspinous portion may develop in the contour of the surrounding structures and become curved.

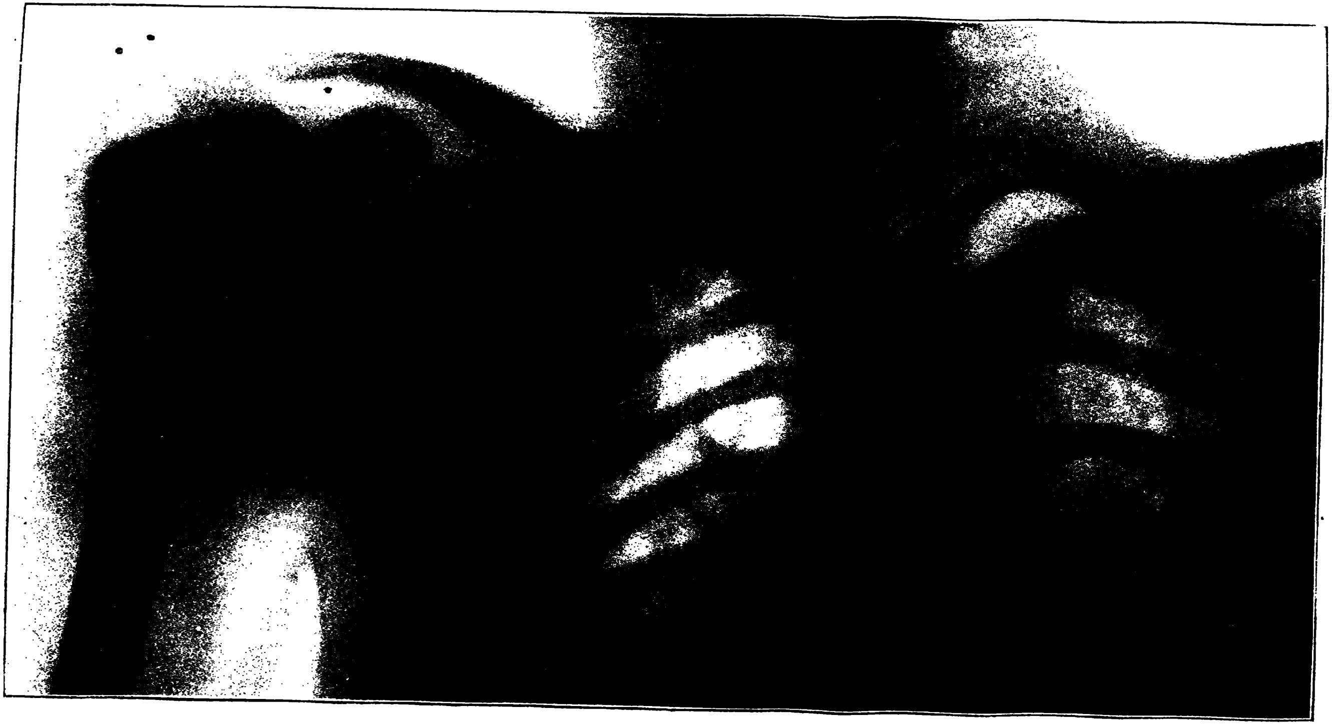
(*c*) Prolongation or rounding of the superior median angle.—Twenty cases, or 18·5 per cent, show a definite bony prolongation at the superior angle or upper third of the median border. In several, an exostosis or bony plate was palpable. Many cases likewise show a broadening of the superior angle—a condition normal to the lower vertebrates.

(*d*) Exostosis and Articulations.—Thirty-four cases, or 25 per cent, show a bony, fibrous, or cartilaginous attachment to the vertebral column. Twenty-seven of these were bony.[1] The abnormal bone usually runs from the superior median angle, or the upper third of the median border, to the transverse process of a cervical (fourth to seventh) vertebræ. In one case (Lameris) a strong band ran from the base, at the inferior angle, to the fourth dorsal vertebra. The osseous union is usually by means of a triangular-shaped bone whose base rests upon the scapula, and the apex upon the transverse process of a vertebra. The union is either by means of cartilage at one or both ends, or by direct bony growth without cartilaginous intervention. (Figs. 30 and 31.)

As to the origin of this bony articulation. Is it of primary or secondary growth? Willett and Walsham[2] believe it to be of primary growth, and advance certain cogent arguments, regarding it as a supra-scapula, which has become secondarily fused with the spine. In fact, it is a peculiar development of the suprascapular epiphysis which normally exists as a narrow ridge

[1] In three of my cases this was present, and in one operated on by me a bony plate was found on the right side, and a fibrous plate on the left.

[2] *Loc. cit.*



Antero-Posterior Skiagram of H. Augustus Wilson and J. Torrance Rugh's Case in Figs. 28 and 29, showing the Ossified Mass between the Left Scapula and Cervical Spine, and the Congenital Scoliosis to the left

of bone lying posterior to the scapula, and is therefore homologous to the supra-scapular bone of some of the lower vertebrates.

Associated Abnormalities.—Defects of the Ribs and Vertebræ.—

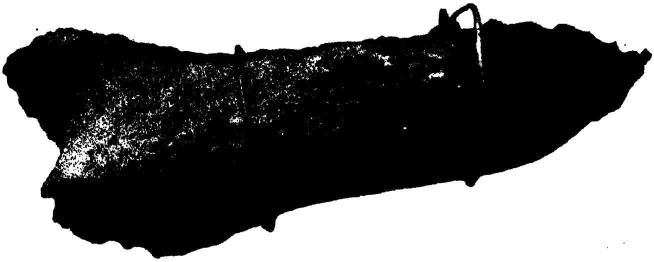


FIG. 30.—Drawing of the Portion of Bone removed from H. Augustus Wilson and J. Torrance Rugh's case (Figs. 24-27). On the left an articular surface with the spine existed, and on the right a second articular surface for the scapula.

These were found in 22 cases, or 16 per cent. Two cases presented cervical ribs on the side opposite to the deformity. Spina bifida in the cervical region was observed in five cases, and spina bifida occulta from the second lumbar vertebra to the sacrum was noticed

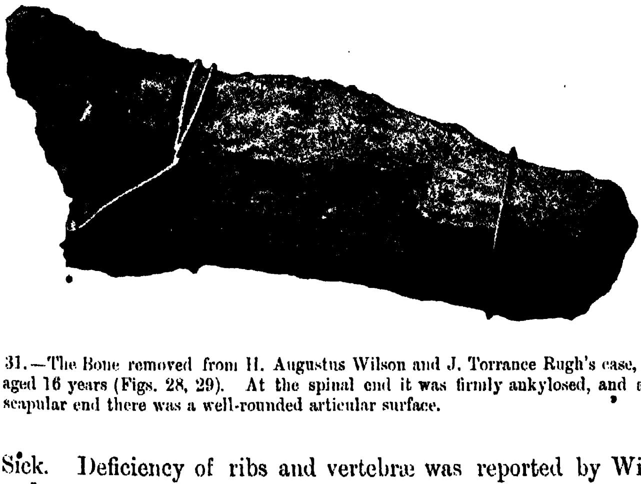


FIG. 31.—The Bone removed from H. Augustus Wilson and J. Torrance Rugh's case, a girl aged 16 years (Figs. 28, 29). At the spinal end it was firmly ankylosed, and at the scapular end there was a well-rounded articular surface.

by Sick. Deficiency of ribs and vertebræ was reported by Willett and Walsham; displacement of the spines with fusion by Hibbs; fused and irregular ribs by Fairbank; missing ribs by Graetzer, Fairbank, and Milward.

Defective Musculature.—The trapezius is the muscle most often affected and is weak in every case. It is sometimes completely absent or defective in some of its parts. The pectoralis major was completely deficient in one case, partially defective in two. Complete absence of the sterno-mastoid was observed by Kayser. Other muscles affected are the serratus magnus, levator anguli scapulæ, infra-spinati, latissimus dorsi, teres major, pectoralis minor, and the rhomboids.

Humerus and Clavicle.—In 18 cases, shortening of the humerus on the affected side was reported, and of the clavicle in 12 cases.

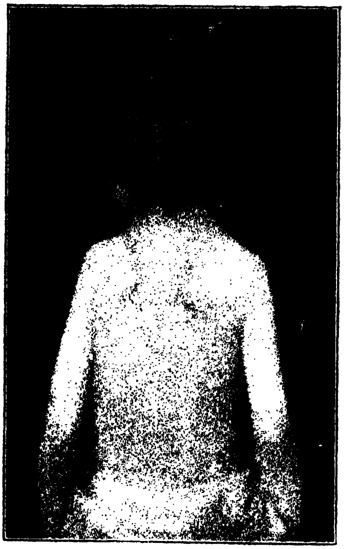


FIG. 32.—Bilateral Sprengel's Shoulder in a girl, aged 5 years.

Other deformities of a bewildering variety are found, and are more frequently seen on the side of the elevated scapula.

As to its *causation*, intra-uterine malposition has been cited by Sprengel,[1] who believed the deformity to be due to the arm having been for some reason displaced behind the back, and retained there by pressure of the uterine walls. It can be shown experimentally that the shoulder is then pushed upward. The effect of amniotic adhesions has been invoked,[2] and even intra-uterine anterior poliomyelitis has been suggested, although it must be new to all of us that anterior poliomyelitis may be accompanied by the formation of new bone. All our experience is to the contrary. Kausch[3] believes defective development of the lower portion of the trapezius to be the cause. Neuro-muscular theories, based on the analogy of disturbances in certain neurons, have been advanced, but without proof.

Briefly, embryology teaches us that the primitive anterior limb

[1] *Loc. cit.*

[2] Schlange, *Berl. klin. Wochenschr.*, 1892, Jahrg. 29. Also *Transac. 22nd German Surgical Congress*, 1893, Band ii. S. 212; and *Arch. f. klin. Chir.* Band xlvi.

[3] *Centralbl. f. Chir.*, 1901, No. xxii.; and *Mitteil. an d. Grenzgeb.* Band ix. Heft 3, sections 415-444.

is a cervical appendage.[1] The early history of the human embryo, together with the points of origin of the nerve-supply to the upper extremity, confirm this view. Sprengel's shoulder may, therefore, be regarded as a failure in the normal "descensus scapulæ," that is, an arrest, combined with maldevelopment of the embryonic shoulder girdle. To this all the effects[2] seem to point. The development of

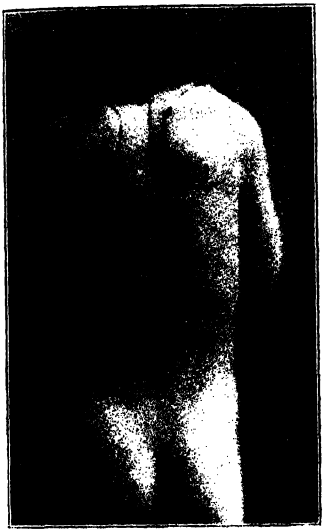


FIG. 33.—The same case as in Fig. 32, before operation. The outlines of the scapulæ are indicated, also the right cervico-dorsal scoliosis. The excessive fulness of the right side of the neck, due to a Bony Omoplate, is seen. This plaque articulated with the spine and scapula. On the left, the union between the spine and scapula was entirely ligamentous.

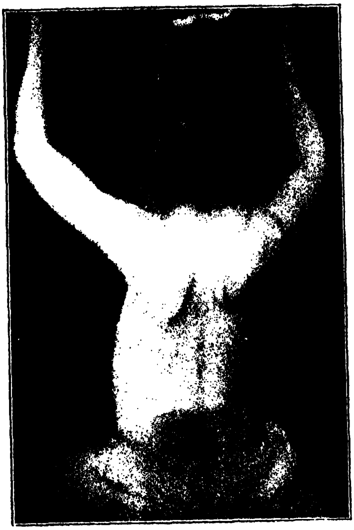


FIG. 34.—The appearance presented by the patient in Figs. 32 and 33 one year after the operation. The arms are raised well above the horizontal, the scapulæ have descended, and are more nearly normal in shape.

an abnormal rudiment between the spine and the scapula does not militate against the view that we are dealing with defective descent of the scapula, inasmuch as this piece of bone, whilst it prevents

[1] Cf. Hutchinson and Bowlby (*Path. Soc. Trans.* and *B.M.J.*, 1894), who remark that the high position of the scapula in these cases corresponded with the normal primitive condition of the limb in the human embryo.

[2] A. J. Steele, *Trans. A.O.A.*, 1902, p. 1819, describes two cases thus: "The entire bone is smaller than its fellow, and the upper angle is prominent at the base of the neck. In general terms the scapula is shorter from above down, and wider relatively from side to side."

descent of the scapula, obviously could not explain any active elevation.[1]

FIG. 35.—Left Sprengel's Shoulder in a child of 2 years, the degree of elevation of the left arm before operation.

FIG. 36.—Posterior view of same case as in Fig. 35.

FIG. 37.—The same case as in Figs. 35, 36, after operation. The Increase of Movement at the Left Shoulder Joint is evident.

FIG. 38.—Posterior view of patient in Figs. 35, 36, after operation.

Treatment.—Some cases require no treatment at all. In others

[1] Chievitz, Copenhagen, 1899: "A Research on the Topographical Anatomy of the Full Term Human Fœtus *in situ*," points out that during fœtal life the nerves of the

active and passive movements and gymnastic exercises, planned to overcome the restrictions to abduction and elevation of the shoulder, will be sufficient. But these measures are not likely to succeed when a rudimentary plate of bone is present, and more particularly when this plate is ankylosed to the spine. The surgeon should not be satisfied with movements and exercises until the arms can be so elevated above the head that the palms of the hands are made to meet in that situation, and until the child can lay the flexor surface of the wrist on the back of the neck. In most cases, either on account of the deformity or because of the limitation of movement, operative interference may be justifiably undertaken.

The operation which the author has practised in three cases has been carried out through a vertical incision between the scapula and the spine. The trapezius is detached from the spine, the subjacent scapulo-vertebral muscles are freely divided, and if a supernumerary plate of bone is present it is removed, or if a fibrous plate is present it is dissected out. If it happens that the vertebral border of the scapula is actually lying over the spinous processes, a portion of the scapula should be excised. In one instance the writer found this necessary.[1] After the wound has healed, exercises both active and passive must be practised for some months until the movements of the arms are quite free.

In some instances where a fibrous band joins the spine and scapula an extensive subcutaneous section may be sufficient. In a girl it is important to consider the desirability of doing so in order to avoid extensive scarring.

BIBLIOGRAPHY

ARNOLD. American Journal of Orth. Surgery, July 1906.

BEELY. Scoliosis capitis. Zeitschr. f. orth. Chir., 1892, Bd. xi.

BENDER. Zur Etiologie des Schulterblatthochstandes. Münch. med. Wochenschr., 1903, 7.

BENDER. Münch. med. Wochenschr., 1903, 1, 293.

BOLTEN. Über den angeborenen Hochstand des einen Schulterblattes. Münch. med. Wochenschr., 1892, 38.

BOURRET. Sur un cas d'élévation congénitale de l'omoplate. Rev. d'orthop., Paris, 1907, 2 s., viii. 47-50.

brachial plexus pass horizontally outward instead of obliquely, and the angle of the scapula reaches to the 5th rib instead of to the 7th, as in later life.

[1] As in Fröhlich's case and one of Hoffa's, where the upper angle of the scapula impinging against the spine prevented elevation of the arm. This portion of the scapula was accordingly excised. Also in Sands' case, *New York Med. Jour.*, 1888, p. 583.

BRADFORD and SOUTTER. Elevation of the Scapula. Boston Med. and Surg. Jour., Jan. 22, 1903.

BULOW-HANSEN. Ein operierter Fall von angeborenem Hochstand der Scapula. Nordiskt Medicinskt Arkiv, 1901, 3^e.

CAPELLE. Ein Fall von Defekten in der Schultergürtelmuskel und ihre Compensation. München, 1905, Inaug. Diss. Kastuber and Callavey, 38 pp.

CAUTURE. Rev. d'orthop., 1892.

CHIEVITZ. A Research on the Topographical Anatomy of the Full-term, etc. Copenhagen, 1899.

COLLIER. Transactions of the Society for the Study of Disease in Children, 1902.

DAMSCH. Über anatomische Befunde bei sogenannten kongenitalen Muskeldefekten. Verhandl. d. Kongresses f. innere Med., 1891, p. 519.

EHEHART. Über angeborenen Schulterhochstand. Beitr. z. klin. Chir., Tübingen, 1904, xliv. 470, Heft 2.

EULENBURG. Beitrag zur Dislokation der Scapula. 37. Versammlung deutscher Naturforsch. und Ärzte, Karlsbad, 1868.

EULENBURG. Hochgradige Dislocation der Scapula, bedingt durch Retraktion des Musculus levator scapulae. Archiv für klin. Chir. Bd. iv.

FAIRBANK. Cases of Sprengel's Shoulder. Trans. Clin. Soc. London, 1905, xxxviii., 200, 2 pl. ; Lancet, Nov. 5, 1904.

FREIBERG. Malposition of the Scapula. Annals of Surgery, May 1899.

FRÖHLICH. Ein Fall von kongenitalem Hochstand der Scapula. Zeitschr. f. orth. Chir. Bd. xi. 1, vii.

GIBNEY. Trans. Am Orth. Assoc., 1901, p. 308.

GOLDTHWAIT and PAINTER. Congenital Elevation of the Shoulder. Boston Med. and Surg. Jour., 1901, 2.

GOURDON. Quatre cas de surélévation congénitale de l'omoplate. Annales de chirurgie et d'orthopédie, 1901, 2.

GOURDON. Surélévation congénitale de l'omoplate droite. Jour. de méd. de Bordeaux, 1905, xxxv. 83-85.

GOPPERT. Zentralbl. f. die Grenzgeb. f. Med. und Chir., 1900.

GRAETZER. Congenital High Shoulder. Mitteilungen a. d. Grenzgeb. d. Med. u. Chir., Jena. Third Supplementary number, memorial to Mikulicz.

HAROUTIOUN. De la luxation congénitale de l'omoplate ou maladie de Sprengel. Thesis. Nancy, 1904, E. Claude, p. 145.

HEINECKE. Eine seltene Verschiebung des Schulterblattes. Zentralbl. f. Chir., 1886, 2.

HIBBS. Med. Rec. N.Y., 1903, lxiv., 168-171. Archiv für Orthop., Wiesbad., 1904, ii. 40-50.

HIRSCH. Über einen Fall von doppelseitigem angeborenem Hochstand der Schulterblätter. Zeitschr. f. orth. Chir. xiii., xv.

HOEDLMOSER. Sprengel'sche Difformität mit Cucullarisdefekt. Wiener klin. Wochenschr., 1902, 52.

HOFFA. Ein Fall von angeborenem Hochstand des einen Schulterblattes. Würzburger phys.-med. Gesellschaft, 1892, 7.

HOFFA. Orthopädische Literatur, 1904.

HOLZ. Angeborene Verschiebung des Schulterblattes nach oben. Med. Korrespondenzblatt d. württembergischen ärzt. Landesvereines, 1896, 33.

HONSELL. Doppelseitiger Hochstand der Schulterblätter. Beiträge z. klin. Chir., 1899, Bd. xxiv.

HORWITZ. Amer. Jour. Orth. Surg., vol. vi. No. 2, pp. 260-311.

HUTCHINSON. Deformity of the Left Shoulder Girdle. Trans. Path. Soc. London, 1894, vol. lxv. p. 224 ; Brit. Med. Jour. i. 1894, p. 634.

JEDLICKA. Wien. klin. Rundschau, 1904, xviii. 508.

JONES. Two Cases of Congenital Elevation of the Scapula. Medical Press and Circular, London, 1901, p. 654.

JOUON. Nouvel exemple de refoulement congénital de l'omoplate par en haut. Rev. d'orthop., 1899, 3.

JOACHIMSTAL. Fortschritte a. d. Gebiete d. Röntgenstrahlen, No. 2.

KAUSCH. Mitteilungen a. d. Grenzgeb. d. Med. u. Chir., 1902, ix. 3.

KAUSCH. Cucullarisdefekt als Ursache des kongenitalen Hochstandes der Scapula. Zentralb. f. Chir., 1901, 22.

KAYSER. Über Hochstand der Scapula mit kongenitalen Hals- und Schultermuskeldefekten. Deutsche Zeitschr. f. Chir., 1903, Bd. lxviii.

KEYSER. Congenital Elevation of the Shoulder. Trans. Clin. Soc., London, 1903-1904, xxxvii. 230.

KEYSER. Lancet, London, 1905, i. 1333.

KILVINGTON. Intercolon. M. J. Australas., Melbourne, 1904, ix. 47.

KIRMISSON et JOUON. Nouvel exemple de refoulement congénital de l'omoplate. Rev. d'orthop., 1899.

KIRMISSON. De quelques malformations congénitales de l'omoplate. Rev. d'orthop., 1893, 5.

KIRMISSON. Nouvel exemple de malformation congénitale de l'omoplate. Rev. d'orthop., 1897, 5.

KIRMISSON. Rev. d'orthop. Paris, 1904, 4, s. 2, pp. 31-46.

KIRMISSON. Comp. rend. Soc. d'obst., etc. Paris, 1903, v. 112-115.

KÖLLIKER. Bemerkungen zum Aufsatz von Dr. Sprengel. Archiv f. klin. Chir., 1891, Bd. xli. S. 925.

KÖLLIKER. Zur Frage des angeborenen Hochstandes des Schulterblattes. Zentralblatt f. Chir., Juli 1895.

KÖLLIKER. Die operative Behandlung der Sprengel'schen Deformität bei Funktionsstörungen des Schultergelenks. Verhandl. d. deutschen Gesellschaft f. Chir., 1902.

KONING. Verhandl. d. deutschen Gesellschaft f. Chir., 1893, 22. Kongress, Berlin.

KRECKE. Chirurgische Demonstrationen im ärztlichen Verein zu München. Münch. med. Wochenschr., 1896, S. 509.

LAMERIS. Archiv f. klin. Chir. Berlin, 1904, xviii. 517-535.

LAMM. Über die Kombination von angeborenem Hochstand des Schulterblattes mit muskularem Schiefhals. Zeitschr. f. orth. Chir. Bd. x. Heft 8.

McBURNEY. N.Y. Med. Jour., 1888.

MAYDL. Sborn. klin. v. Praeze, 1903-4, v. 73-146, 3 plates. (Study of elevation of scapula.)

MERCIER. Bull. Soc. d'obst. de Paris, 1904, vii. 148-150.

MILWARD. Brit. Med. Jour., London, 1904, ii. 1636.

MILO. Ein Fall doppelseitiger Sprengel'schen Deformität. Zeitschr. f. orth. Chir. Bd. xi., 1899, Heft 6.

MILO. Een geval von dubbelsijdige Sprengel Difformitat. Weekblad voor Geneeskunde, 1897, p. 695.

MOHR. Zur Kasuistik des beiderseitigen angeborenen Schulterblatthochstandes. Zeitschr. f. orth. Chir., 1903, xi. 2.

MOLLIER. Über die Statik und Mechanik des menschlichen Schultergürtels. Festschrift für Kupfer, June 1899.

MONNIER. Sur un nouveau cas de déplacement congénital de l'omoplate. Rev. d'orthop., 1899, 2.

MOUCHET. Gaz. des hôp., Paris, 1903, lxiv. 985-991.

MÜLLER. Über den angeborenen und erworbenen Hochstand des Schulterblattes. Diss., Leipzig, 1902.

NEUMAN. Zur Frage einer ätiologischen Bedeutung des Cucullarisdefektes für den Schulterblatthochstand. Wiener klin. Wochenschr., 1903, 36.

NOVÉ-JOSSERAND. Position élevée de l'omoplate. Lyon méd., 1899. Contribution à l'étude de la position élevée de l'omoplate. Revue mensuelle des maladies de l'enfance, mars 1900.

NOVÉ-JOSSERAND. Anomalie de position de l'omoplate par contracture du rhomboïde. Gaz. hebdom. de méd. et de chir., 1900, xlvii. p. 510.

OBERSTEINER. Rückgratsverkrümmungen, etc., bei Muskeldefekten. Wiener klin. Rundschau, 1902, 16.

PANKOW. Über den angeborenen, insbesondere beiderseitigen Schulterblatthochstand. Diss., Leipzig, 1900.

PARISIL. De la surélévation de l'omoplate congénitale. Jour. de chir. et Ann. Soc. belge de chir. Brux., 1907, vii. 58-63, 2 pl.

PERMAN. Tvanne fall af medfood fortsgutning uppot af Skulderblat. Nordiskt. Medicinskt Arkiv, 1892, xxiv. N.F.LL.

PISCHINGER. Drei Fälle von angeborenem Hochstand der Scapula. Münch. med. Wochenschr., 1897, S. 1471.

PITSCH. Ein Fall von angeborenem Hochstand der Scapula. Zeitschr. f. orth. Chir., 1899, Bd. vii.

PORT. Münch. med. Wochenschr., 1899, p. 814.

RAGER. Drei Fälle von angeborenem Hochstand des Schulterblattes. Zeitschr. f. orth. Chir. Bd. ix., 1901, Heft 3.

ROBINSON. Trans. Society for Study of Disease in Children, 1902.

SAINTON. Sur un nouveau cas de déplacement congénital de l'omoplate. Rev. d'orthop., 1898, 6.

SAINTON. Note sur un cas de surélévation congénitale de l'omoplate. Ibid. 1899, 1.

SANDS. N.Y. Med. Journ., 1888, p. 582.

SCHLESSINGER. Zur Lehre von angeborenem Pectoralisrippendefekt und dem Hochstand der Scapula. Wiener klin. Wochenschr., 1900.

SCHLANGE. Demonstration von angeborenem Hochstand der einen Hälfte der Scapula. Berl. klin. Wochenschr., 1892.

SCHLANGE. Über Hochstand der Scapula. Verhandlung d. deutschen Gesellschaft f. Chir., 1893. Archiv f. klin. Chir., Bd. xlvi.

SICK. Über angeborenen Hochstand des Schulterblattes. Deutsche Zeitschr. f. Chir. Bd. lxvii.

SPRENGEL. Die angeborene Verschiebung des Schulterblattes nach oben. Archiv f. klin. Chir., 1891, Bd. xlii.

STEELE. Trans. Amer. Orth. Assoc., 1902, p. 18.

STILES. Lancet, May 28, 1904, p. 1905.

TILANUS. Over Sprengel's Diffortmiteit. Ned. Tijdschrift voor Geneeskunde 1897, Deel ii. 5.

TRIDON. Rev. d'orthop. Paris, 1904, v. pp. 435, 489.
TRIDON. Rev. d'orthop. Paris, 1905, vi. p. 71.
VIRDEN. A Case of Congenital Displacement of the Scapula. Pediatrics, New York, 1899, vii.
VOROBYEFF. Russk. Vrach. St. Petersb., 1904, iii. 1179-83.
WACHTER. Über angeborenen Hochstand des Schulterblattes. Diss., Strassburg, 1901.
WATERMAN. Acad. of Med., N.Y. Orth. Section, April 1902. Rev. d'orthop 1903.
WIESSINGER. Demonstration im ärztlichen Verein zu Hamburg. Münch. med. Wochenschr., 1896, S. 664.
WILLETT and WALSHAM. Trans. Royal Med. and Chir. Soc., 1880-83.
WILSON and RUGH. Two Cases of Anomalous Spinous Process of the Seventh Cervical Vertebra articulating with Scapula. Annals of Surgery, April 1900, Philadelphia.
WINKEL. Münch. med. Wochenschr., 1896, S. 389.
WITTFELD. Über den angeborenen Hochstand der Scapula. Diss., Bonn, 1901.
WOLFHEIM. Über den angeborenen Hochstand der Scapula. Diss., Berlin, 1895. Zeitschr. f. orth. Chir. Bd. iv., Bd. xvii.
ZESAS. Über den angeborenen Hochstand des Schulterblattes. Zeitschr. f. orth. Chir. Bd. xv. Heft 1.

CHAPTER II

TORTICOLLIS OR WRY-NECK

Definition—Varieties—Congenital Wry-Neck, Frequency, Causation, Pathology, Symptoms, Treatment—Posterior Wry-Neck—Lateral Wry-Neck—Symptomatic Torticollis.

Synonyms—Latin, *Caput obstipum, Collum distortum*; French, *Torticolis, Cou tortue*; German, *Schiefhals.*

Definition.—A deformity, either congenital or acquired, characterised by lateral inclination of the head to the shoulder, with torsion of the neck and deviation of the face.

Varieties.—A more or less permanent twisting of the neck is a symptom of a number of conditions which have very little in common. Congenital torticollis is due to lesions of the sterno-mastoid muscle; spasmodic torticollis in most cases is not associated with any obvious source of irritation, and is now regarded as due to cerebral changes.[1] Wry-neck can also be traced to reflex irritation, and it is seen in local painful conditions, such as rheumatic myositis. It is also met with in spinal caries as a result of the muscular irritation and destruction of bone. A comprehensive classification, based on the literal meaning of the word torticollis, although of use from the point of view of differential diagnosis, cannot give any idea of the relative importance and frequency of the various kinds. The usual division into true and false torticollis, or essential and symptomatic, is not very helpful.

Perhaps the best method is to describe here congenital wry-neck, and refer to other conditions in which the symptom of wry-neck is met with. Spasmodic wry-neck is more appropriately treated in the section on "Deformities arising from Nerve-Lesions."

[1] Sir Victor Horsley tells the author that in fatal cases he has found well-marked cerebral arterio-sclerosis, and many of these people are prematurely aged and have hard arteries.

Congenital Wry-Neck

Frequency.—Congenital torticollis is a comparatively rare condition. Royal Whitman[1] states that during twenty-seven years 507 cases of torticollis were treated at the Hospital for the Ruptured and Crippled, and of them 87 were regarded as congenital. During the same period, however, more than 5000 cases of club-foot were met with. Of 2324 patients with general surgical affections seen by the author at the Evelina Hospital for Children, wry-neck was met with in 8 only; and of 5079 cases coming under the author's care at the Royal National Orthopaedic Hospital, torticollis was met with 15 times. Further, in 5190 patients coming under the author's personal observation in other ways the deformity was found 9 times.

It is more common in females than in males. Of the 87 cases mentioned by Whitman, 46 occurred in girls. Kempf[2] collected 37 cases, 24 being females and 13 males.

Causation.—The chief factors bearing on the incidence of congenital torticollis are succinctly put by Nové-Josserand and Charles Vianny[3] in the following manner:—

1. Congenital torticollis may be either met with at birth, or may develop during the early months of life. In either event it presents the same clinical features and anatomical lesions.

2. It may be hereditary, and co-exist with other malformations, such as club-foot, congenital luxation of the hip, which are to-day considered as results of intra-uterine compression, or of some initial malformation of the germ. It is also closely related to difficulty in delivery arising from pelvic presentations, impaction of the head, and fœtal malpositions. A history of delivery by forceps is often forthcoming; and sometimes lesions, such as obstetrical paralysis of the shoulder and upper extremity, co-exist; but the history of dystocia is by no means universal.

3. The lesion which characterises torticollis is nearly always limited to the sterno-mastoid muscle. To-day it appears certain that in some cases both sterno-mastoids are affected in varying degrees, and present the same type of lesion. This always has the characters of an interstitial fibro-myositis, and there is probably hyaline

[1] *Orthopedic Surgery*, 2nd ed. p. 626.

[2] *Deutsch. Zeitschr. f. Chir.* vol. lxxviii., June 1904.

[3] *Rev. d'orth.*, Sept. 1, 1906.

degeneration of the muscular fibre, such as is met with in Volkmann's ischæmic paralysis.

FIG. 39.—Congenital Torticollis on the right side. Before operation.

4. Congenital torticollis is curable by operative measures directed to the sterno-mastoid, and to that chiefly.[1]

Theories of Causation.—Many have been suggested, but a few only can be dealt with at length.

(*a*) *Stromeyer's View.*—His opinion was that during labour the sterno-mastoid was injured or ruptured and the contraction of the resulting scar led to shortening of the muscle. In support of this view are the facts that rupture of the sterno-mastoid is an accident known to occur during labour; that in a definite proportion of cases of congenital torticollis there is a history of a localised swelling of the sterno-mastoid having been seen immediately after birth, or within a couple of

FIG. 40.—The same case as in Fig. 39. After operation.

[1] Certain authors have advocated section of the scalenus anticus, but the writer has not found it to be necessary, although in some cases portions of the deep fascia in the posterior triangle must be divided.

weeks after that event. This swelling has been regarded as a localised effusion of blood, or hæmatoma, due to rupture of the muscle fibres. Latterly, however, the existence of a hæmatoma has been doubted, and the term pseudo-hæmatoma has been adopted instead. We know that in a large proportion of cases there is a history of difficult labour. Thus, in 23 of 40 cases collected by Maass[1] the presentation was pelvic. Mikulicz[2] has offered an ingenious explanation of the frequency of injury to the sterno-mastoid in delayed birth of the head. Owing to compression of the umbilical cord forced respiratory movements occur, whilst the fœtal head is still engaged in the maternal passages. The sterno-mastoid is one of the muscles of forced inspiration, and therefore is contracted, so that tension of the neck, whilst the muscle is rigid, will be more likely to rupture it than if it were relaxed. This theory, however, appears to me to be fanciful and without proof.

Of late years, owing to the opportunities afforded by operative resection of the muscle for studying the structural changes, Stromeyer's theory has been considerably shaken. It fails to explain cases in which the deformity has been seen in extra-uterine gestation,[3] and all those in which the characteristic structural changes have been seen immediately after birth,[4] for such changes require a considerable time for development. As often as not, there is no history of any swelling of the sterno-mastoid. When a pseudo-hæmatoma is present, it has none of the clinical characters of an effusion of blood, and when incised and a portion removed, no traces of blood or of blood-pigment have been found microscopically.[5] It is quite certain that torticollis does not always follow the development of a pseudo-hæmatoma,[6] nor is rupture of the sterno-mastoid always

[1] *Zeitschr. f. orth. Chir.*, 1903, p. 416. [2] Joachimstal's *Handb.* p. 437.

[3] Joachimstal and Volcker, *Handb. f. orth. Chir.* p. 432.

[4] Nové-Josserand's *Rev. d'orth.*, Sept. 1, 1906.

[5] Cf. Nové-Josserand (*loc. sup. cit.*) and case 41 in *Deformities*, 1st ed. p. 191. In this connection the footnotes on page 187 of that volume throw some light upon the point at issue. Pincus had an opportunity of examining the body of a child aged fourteen days. A swelling the size of a hazel nut developed in the left sterno-mastoid two days after birth. Microscopically, it was composed of chronic interstitial myositis, with no trace whatever of blood-pigment. Obviously it must have arisen in intra-uterine life.

[6] See cases 39 and 40, *Deformities*, 1st ed. p. 190. Also in 7 cases of swelling in the sterno-mastoid collected by Whitman (*Transac. of the Amer. Orthop. Assoc.* vol. iv. p. 292) no torticollis followed. In 18 cases collected by H. H. Clutton (*St. Thomas's Hospital Reports*, vol. xvii. 1888), where congenital tumour or induration of the sterno-mastoid was present, in only two did wry-neck follow. Keetley (*Orthopædic Surgery*, p. 200) states that of 30 cases of congenital hæmatoma of the sterno-mastoid observed by Clutton, Edgar Willett, and D'Arcy Power, only 11 eventually had wry-neck.

followed by torticollis. Lüning and Schulthess also state that they know of at least two cases in which not the slightest limitation of movement resulted. As Peterson points out, tearing of a muscle leads to lengthening and not shortening, a fact to which Sir Thomas Smith also called attention in the discussion on Mr. D'Arcy Power's paper at the Royal Medical and Chirurgical Society, 24th January 1893.

Experiments on animals have produced neither the typical swelling and muscular contracture nor the myositic changes; and when true hæmatomata have been produced in animals, they have not been followed by structural changes.[1] In some cases the typical changes in the presumably injured sterno-mastoid muscle in children have also been observed, although to a less degree, in the muscle on the other side.

Finally, injury to the sterno-mastoid during birth is more likely to occur if intra-uterine shortening has taken place.[2]

(*b*) The difficulties in accepting the simple traumatic view have led to a theory advocated chiefly by Mikulicz and Kader, that we are dealing with injury, with subsequent microbic infection. Signs of the latter are entirely wanting, however, and no organism has been isolated.

(*c*) Syphilis is an infective condition, but its manifestations are not associated with the formation of pus, unless pus-forming organisms are introduced into the lesions. While the final stages of syphilis are of a sclerotic character, the author has shown that cases of localised thickening of the sterno-mastoid in syphilitic children yield to appropriate treatment, and they escape the deformity of torticollis.[3]

(*d*) Since neither the simple traumatic theory of Stromeyer nor the other causes just mentioned serve to explain the occurrence of wry-neck in extra-uterine gestation, or in those cases in which the structural changes were already well marked at birth, various

[1] Witzel, *Zeitschr. f. Chir.* Bd. xviii., 1883; and Heller, *ibid.* Bd. xlix. p. 234.

[2] Lüning and Schulthess have published the details of a post-mortem examination of a child, aged 5 months, delivered by forceps, who showed at the time of birth a swelling of the middle part of the right sterno-mastoid muscle, which was shortened as much as two-thirds of an inch (*Zeitschr. f. orth. Chir.*, 1891, Bd. i. Heft 1.

In a case described by Häusinger (Joachimstal's *Handb.* p. 432) of a child a few days old, while the normal muscle was found to be 9 centimetres long, the affected one was only 6·5 cm.

[3] *Deformities*, 1st ed. cases 36, 37, 39, 40; cf. also Mikulicz (*Centralb. f. Chir.*. 1895, No. i. S. 2), Kader (*Beitr. z. klin. Chir.* Bd. xxvi., 1900, S. 188), Kempf (*Deutsch. Zeitschr. f. Chir.*, 1904).

mechanical theories have been advanced. Such are intra-uterine malposition, fixation of the head and neck by amniotic adhesions, and the effect of obliquity of the fœtal head in normal presentations. These fail to explain why a special lesion of the sterno-mastoid is present, and why the neighbouring parts are not involved as well.

(*e*) Suggestions as to a nervous origin do not call for discussion. The difficulties in the way of accepting either a central (Golding-Bird), medullary (Gallavardin and Lavy), or peripheral (Kempf) origin of congenital torticollis are insurmountable.

(*f*) *The Ischæmic Theory.*—In 1881 Volkmann described ischæmic paralysis, in which a peculiar degeneration of the muscle fibres is seen after prolonged partial obstruction of the circulation. Similar microscopical changes have been observed in the sterno-mastoid muscle in congenital torticollis. The similarity has been noted by Volcker,[1] Kempf,[2] and others; but no satisfactory explanation was put forward until Nové-Josserand and Vianny, from a careful and experimental study of the blood-supply of the muscle, showed that it is of such a character that it can be readily interfered with. The sternal portion and middle of the muscle are supplied by the sterno-mastoid branch of the superior thyroid artery. When this is ligatured, injection material thrown into the common carotid or subclavian vessels fails to appear in the area of distribution of the artery in question, showing that it has little or no anastomoses with its neighbours. Further, the circulation in this small muscular vessel is readily obstructed in certain positions of the head. Thus, experimentally, in the bodies of twenty newly born infants it was shown that lateral flexion of the head, with elongation of the neck, and particularly lateral flexion, with torsion of the neck, prevented any injection reaching the muscle. The injection was arrested at the anterior border of the muscle, the lumen of the artery being obliterated at that spot.

To the author the ischæmic theory is the most satisfactory in general. It explains the uniform character of the lesion and the nature of the structural change. It also correctly assigns the origin of the pseudo-hæmatoma, which is nothing more than post-obstructive œdema. And, finally, it elucidates the partial distribution of the lesion and the absence of primary involvement of the surrounding parts.

In certain cases the ischæmic theory does not hold good; for

[1] "Das Caput obstipum," Brün's *Beiträge*, Bd. xxxiii., 1903.
[2] *Zeitschr. f. orth. Chir.* Bd. ii.

example, the case described by Lüning and Schulthess[1] is obviously a muscular anomaly similar to others met with elsewhere.

Pathological Anatomy.—Microscopical examination of excised portions of the affected muscle show that the changes consist of a sclerotic interstitial myositis, together with a special lesion of the actual muscular fibre, the "waxy degeneration" of Zenker, culminating in a more or less complete hardening of the muscle and subsequent shortening. The sternal portion is chiefly affected. M. Paviot reports thus of one of Nové-Josserand's cases: "The two fragments sent (sternal and clavicular heads) present the same lesions. They only differ in the number of muscular fibres affected. The lesion is everywhere a more or less intense sclerosis in the form of fasciculi or skeins of fibrils or a coarse hyaline fibrosis. At the same time there is the characteristic degeneration of Zenker, swelling of the fibres, glassy condition, and disappearance of the transverse striation. Here and there some fibres persist, with normal striation, but are small in diameter. According to the part of the muscle examined, the sclerosis is more or less intense, but the disappearance of the fibres is always proportional to the sclerosis."

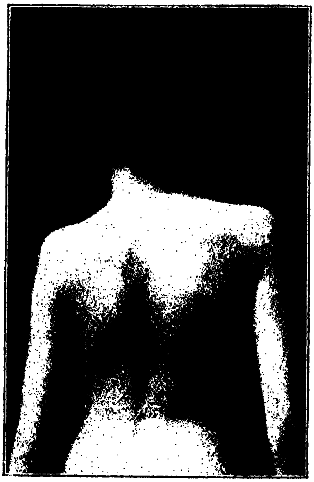


FIG. 41.—Posterior view of a patient with Right Congenital Torticollis, Elevation of the Right Shoulder, and marked Asymmetry of the Trunk, and shifting of the head to the left or sound side.

Symptoms.—Owing to the shortening of the sterno-mastoid muscle, the head is laterally flexed towards the affected side and the face rotated to the opposite side. The chin is raised and carried forward, especially when an attempt is made to extend the head. The lobule of the ear on the affected side is approximated to the shoulder, which is itself raised. A vertical line dropped from the tip of the lobule of the ear falls more or less inside the middle of the clavicle, instead of well outside it. That is to say, the head as a whole is shifted towards the sound side (Fig. 41). If a vertical line is drawn through the centre of the sternum, it will be seen that the bulk of the head is on the non-contracted side, and at the

[1] *Zeitschr. f. orth. Chir.*, 1891, Bd. i. Heft 1.

same time the affected sterno-mastoid runs a much more vertical course than the normal one. On palpation, the affected muscle is hard, but not painful.

With the deviation of the head there are also contraction of the fascia and alterations in the cervical spine. In long-standing cases the platysma, splenius, and scaleni are secondarily shortened. Since the face is deviated to one side, while the eyes are directed forwards, a portion of the visual field in both eyes is in partial use only. This in time, as pointed out by Hübscher,[1] leads to contraction of the field. Joachimstal,[2] in association with Dr. Hugo

FIG. 42.—Right Congenital Torticollis, showing Asymmetry of the Face.

FIG. 43.—The same child as in Fig. 42, two and a half years after Section of the Sterno-Mastoid Muscle. The asymmetry has nearly disappeared.

Wolff, has shown that after wry-neck is cured the visual field expands.

Facial and Cranial Asymmetry.[3]—In infants this is not marked, but as the child grows older it becomes more evident (Fig. 42). Before operation, it is well demonstrated by observing the patient's face as seen in a looking-glass. After operation, when the malposition of the head is corrected, the facial and cranial asymmetry becomes very obvious, and in old-standing cases constitutes for a time a continual source of distress to the patient. Fortunately the asymmetry disappears spontaneously after correction of the torticollis, and the author has been at some pains to ascertain how long

[1] "Symmetrische Einschränkung der Blickfelder bei Torticollis," *Beiträge z. klin. Chir.*, 1893, Bd. x. S. 299.

[2] *Ibid.* 447-449.

[3] Cf. Figs. 39, 42, 44.

a period elapses before the disparity between the two sides of the face ceases to be noticeable. In a child of 8 years very little difference was observable eighteen months after the operation. In another child, aged 13, two and a half years elapsed, and in a boy, aged 16, over three years, before disfigurement ceased to be noticeable.

In an old-standing case, with contraction, for example, of the right sterno-mastoid, it will be found that the measurement from the external angular process of the frontal bone to the angle of the mouth is less on the right side than on the left. The nose deviates to the right, the left half of the lower jaw is longer than the right, and the point of the chin is to the right of the middle line. A line drawn through the symphysis menti to the inter-maxillary and inter-frontal sutures, instead of being straight, is curved, with its convexity to the left. A line drawn from one external canthus to the other, instead of being parallel with a line drawn from one angle of the mouth to the other, converges somewhat on the right. At first sight this gives the impression of simple atrophy of the affected side from muscular disuse, or, as has been suggested, from deficient blood-supply on the affected side. Apart from the fact that lessening of the calibre of the carotid artery on the side of the contraction has not been demonstrated, the atrophy which results from experimental interference with the blood-supply is of a different character from that seen in wry-neck. In the latter there is distorted growth in all directions, and the cranium is also asymmetrical. In a right-sided torticollis the frontal bone is flattened, and the right parietal eminence is more prominent than on the sound side, so that the outline of the cranium is an oblique oval. The left parietal bone is flattened, and the left frontal bone is unduly convex. The deviation of the mesial line of the base of the skull to the left is very striking. A profound alteration, therefore, of the whole of the cranial bones has taken place, a kind of

FIG. 44.—Contraction of both Sterno-Mastoid Muscles, more marked on the Left Side. Note the asymmetry of the face.

twist of the entire skull, which has been well named "scoliosis of the face and cranium."[1]

Scoliosis.—It is pointed out in the article on scoliosis that lateral curvature of the spine is always associated with rotation. In torticollis the cervical spine is laterally inclined and rotated. According to Lorenz this scoliosis may be of two types. In the first no compensatory curve is present, and the centre of gravity of the head falls on the same side of the mid-sacral line as the shortened sterno-mastoid. In the second type the spine is sinuously curved, its upper part being deflected towards the sound side, and a well-marked compensatory curve developed towards the affected side in the dorso-lumbar region. The result is that the head is displaced, so that its centre of gravity falls on the opposite side of the mid-sacral line.

After the wry-neck is cured, the tendency is in most cases for the scoliosis to improve with appropriate treatment. In some instances, however, no tendency to improvement follows, and the scoliosis may steadily progress until a high degree of deformity is attained. The natural inference is that wry-neck should be cured early, so that the osseous changes may be as little marked as possible.

The asymmetry extends to the clavicles, that on the affected side being shorter than the other, as observed by Witzel.[2]

It has been said[3] that the temperature of the parts of the affected side, as tested by a sensitive surface-thermometer, is half a degree lower than on the sound side.

Strabismus does not often result from the deformity, as compensation is effected in the cervico-dorsal spine. Astigmatism is a cause of acquired torticollis, but is not associated with the congenital form. (Figs. 45 and 46.)

Treatment.—The treatment of congenital wry-neck is either manipulative, mechanical, or operative. If, in children, congenital

[1] This is to be regarded, as Joachimstal points out, as an adaptation in the Wolffian sense; and he says that his view is confirmed by the fact that similar changes are met with in long-standing obliquity of the head, quite apart from any contraction of the sterno-mastoid, as, for example, in scoliosis high up in the cervical region. Further, the fact that in time the distortion of the bones disappears spontaneously after the actual torticollis is cured appears to the author to lend support in this instance to the Wolffian theory.

[2] *Deutsch. Zeitschr. f. Chir.* Bd. xviii., 1883. Witzel has also shown by experiments that the artificial production of a hæmatoma in the sterno-mastoid is not followed by contraction of the muscle, either transitory or permanent.

[3] Rédard, *Traité de chirurgie orthopédique*, p. 182.

syphilis is present, mercury should be given in the form of Pulv. hydrarg. cum creta gr. $\frac{1}{3}$ to $\frac{1}{2}$, thrice daily, and a $2\frac{1}{2}$ per cent strength of hydrargyri oleat. rubbed over the tense muscle. The case of Jane C., No. 37, page 189, in the first edition of this work, is an instance of the successful relief of sterno-mastoid induration and slight wry-neck by this means.

Manipulative.—In infants with little deformity, the mother should be told to flex the head laterally to the opposite shoulder,

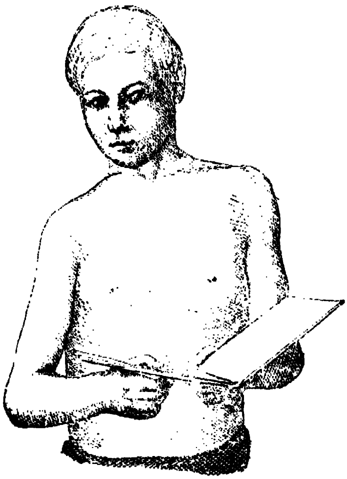


FIG. 45.—"Ocular" Torticollis, due to Astigmatism (Bédard).

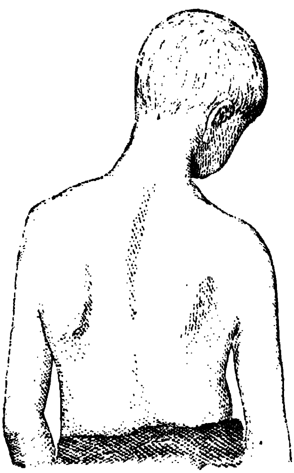


FIG. 46.—Posterior View of the Patient in Fig. 45.

and turn the chin to the same side, several times daily. These movements will often serve to arrest an incipient wry-neck. As the child grows, a leather or poroplastic collar (Fig. 47) may be worn to prevent any return of the deformity.

Mechanical.—In view of the fact that in section of the sterno-mastoid there exists such simple and efficient means of cure, the use of complicated apparatus alone is much to be deprecated. Good results rarely, if ever, follow.

Operative.—The principles which should guide us in undertaking operative measures are :—

(1) To divide completely the tendons, muscular and fascial bands, which prevent restitution of the head.

(2) After the operation, to maintain the improved position by

means of a simple support, and such an one as does not interfere with daily manipulation.

(3) The after-treatment must include at the same time the effective reduction of the deviation of the cervical and dorsal vertebræ.

It is now admitted that subcutaneous tenotomy is not always followed by complete cure of torticollis. This is especially so when the deep fascia and the posterior cervical muscles are adaptatively shortened. As a rule the deformity is not well established until between the first and second years.[1] After that, if simple measures fail, the sooner operation is done the better. It is true that the average age of cases operated upon is much higher than two years, but many patients come very late to orthopædic clinics.

Subcutaneous tenotomy for the relief of torticollis has been abandoned by every surgeon of experience. Apart from the fact that relapses often occur from insufficient division of the muscle, the dangers of the operation are considerable. Important veins lie very close. Immediately behind the sternal head is the anterior jugular vein, reaching outwards to join the external jugular, situated at the outer border of the clavicular head, and there receiving the suprascapular and transversalis colli vein and a branch from the cephalic vein. The external jugular vein passes into the subclavian. Deeply situated behind the sternal and clavicular origins of the muscle are the common carotid artery and internal jugular vein. The latter has been wounded, both in subcutaneous tenotomies and in operations by the open method, and fatal results have been recorded. In some cases, however, either complete ligature, side ligature, or suture of the vein have been successful in arresting the hæmorrhage. Unless the deep cervical fascia is opened, the vein is not reached.

Subcutaneous Section of the Sterno-Mastoid.—Occasionally it has been done in the middle part of the muscle, but, on account of the close proximity of the carotid sheath, section ought never to be attempted at this spot.

The muscle is usually divided at the lower end at one-half to one inch above the clavicle. If the right muscle is affected, the surgeon enters his tenotomy knife from the inner side of the muscle; and if the left side, the puncture is made at the outer side of the muscle. The knife is then passed beneath the muscle, and its edge

[1] Joachimstal, *ibid.* p. 479, records a case of a high degree of torticollis in an infant eight weeks old, who was operated on by Bayer, by the Z-shaped resection of the

is turned towards the surface. The assistant now makes the muscle tense, and it is cut through by a sawing movement of the knife.

The only advantages claimed for the subcutaneous method are that little or no scar is left, and there is less danger of suppuration. The latter point ought not to influence us nowadays.

Lorenz,[1] in order to shorten the after-treatment, has advocated subcutaneous rupture of the muscle, or myorrhexis, much after the manner of his well-known method of dealing with the contracted adductors in congenital dislocation of the hip. At the operation, directly the resistance of the sterno-mastoid is removed, the head is forcibly manipulated and rotated in all directions. This he calls *Modellierendes Redressement*, its objects being to overcome any shortening of the fascia and of muscles besides the sterno-mastoid, and to correct the scoliosis. As far as the myorrhexis is concerned, it is not always possible, even in children in the hands of practised operators.[2] This procedure is not free from danger, as a fatal case occurred in a patient aged sixteen years, as recorded by Reiner.[3] Some surgeons have met with alarming collapse.[4]

Open division of the muscle is the only rational method of treatment. Three situations have been advocated as suitable sites for section of the muscle. These are just below the insertion into the mastoid process, at its origin just above the sternum and clavicle, or in the middle. There are advantages and disadvantages in each.

As to the mastoid operation, (*a*) the muscle can be stripped and well separated from its bony attachments without the danger of dividing or wounding the internal jugular vein.

(*b*) The operation is readily performed, and as most of the wound lies within the line of the hair, the resulting scar is not noticeable. The disadvantage is the length of the incision required.[5]

[1] *Wiener med. Presse*, Feb. 19, 1893; *Centralb. f. Chir.*, 1895, No. v.; *Wiener med. Wochenschr.*, 1902, Nos. ii. and iii.

[2] Joachimstal, *ibid.* p. 462.

[3] *Wien. klin. Wochenschr.*, 1896, No. xliii.

[4] Brackett, *Transac. of Amer. Orth. Assoc.*, 1897, p. 110, "found in a case in which he carried the correction beyond a certain point that the symptoms of collapse were so grave that he had to desist. Subsequently, after the plaster was taken off, he could again induce collapse by over-correcting. He suggested tension on the vagus nerve as the cause." In a subsequent discussion Blanchard stated that it was due to sudden cutting off of the blood-supply to the brain. This is the correct explanation, as was shown by experiments on the cadaver in the fatal case recorded by Reiner.

[5] Bradford and Sever (*Boston Med. Jour.*, August 22, 1907, p. 241) state "that one of the writers has performed the division of the mastoid insertion in three cases. The results have been excellent, and the method is one which is of value in the hands of competent surgeons." But to the author this method does not present any preponderating advantage.

Division of the muscle at its mid-point has been practised by some surgeons, who believe there is less liability to relapse, because the separation of the divided muscle is greater in its middle than at its ends. The incision can also be made in the line of the muscle and in a fold of the neck, and the resulting scar is less disfiguring. But the muscle at this point is thick, and the carotid artery and vein are in immediate contact, so that an unnecessary amount of care and risk is involved. Further, the spinal accessory nerve may easily be divided in its passage through the muscle or at its posterior border.

The division of the muscle above its origin from the sternum and clavicle attacks the muscle where it is most superficial and is most easily reached. Every stage of the operation is seen, and all the vessels are avoided. Complete division, not only of the sterno-mastoid, but of the fascial bands, is possible, and the after-treatment is shortened. Some surgeons[1] have found it necessary to divide the scalenus anticus in addition to the sterno-mastoid, and have recommended it on the ground that correction of the cervical scoliosis is easier. Gerdes[2] employed it in eleven cases, and in Hoffa's Clinic the muscle was divided twice in 120 cases. It is therefore evident that this addition to the operation is rarely called for.

Summing up the methods of open section of the sterno-mastoid, I place unquestionably above all other methods open division of the muscle just above its origin from the sternum and clavicle.

An important question is the direction of the incision. It may be horizontal, oblique, or vertical. The edges of an oblique or vertical incision fall together better, but a somewhat longer incision must be made. If the horizontal line is used, a short incision, not more than 3 to 5 cm. long, is all that is necessary, the skin in this region being easily displaced. Using small retractors, the sheath of the sternal head is exposed; it is opened, and the tendons carefully divided on a director, the division being from before backwards. The clavicular head is then similarly treated, and the fascial bands of the muscle sheath, and of the neighbouring deep cervical fascia, are picked up with dissecting forceps and carefully divided. The size of the gap which follows the retraction of the muscle is considerable, and an inexperienced surgeon is apt to be disturbed at the depth of the resulting hole. When the operation is carefully done, no vessels require tying.

[1] Gerdes, *Centralbl. f. Chir.*, Feb. 9, 1907; Becker, *Centralbl. f. Chir.*, April 20, 1907.
[2] *Centralbl. f. Chir.*, 1895, No. i.

After complete section of the muscle the surgeon or his assistant should take the patient's head in both hands, and hold the shoulders firm. The head should be then brought into an over-corrected position, so as to overcome all contraction of minor muscles. The closure of the wound is of great importance, and minute care should be devoted to it. If the horizontal incision be used, it is found that very frequently the scar widens, and later on becomes very unsightly. Therefore, one or two efficient sutures should be applied, and the edges of the incision brought together either by buried sutures or by Michel's clips. The wound should then be covered with silver foil, and left for four days.

The objection to the horizontal incision is the cicatrix, which is especially important in girls. Even when the skin is drawn up, so that the resulting scar is at first below the clavicle, in time it shifts its position, and appears higher in the neck. As the patient grows, the cicatrix grows too, so that what is quite a small mark in a child is considerable in an adult, and keloid is apt further to complicate matters. The broadening of a horizontal scar made in childhood is often very extensive, owing to the pull on the parts, especially in carrying out manipulations, and the suture scars are very prominent.

With the object of avoiding these disadvantages the author has used an oblique incision along the lower part of the anterior edge of the sterno-mastoid. By retracting very thoroughly, the whole width of the muscle can be divided, including the fascial bands in the posterior triangle. The cicatrix falls in a natural fold of the neck, and does not stretch in the same way as the horizontal one.

The oblique incision has been employed on several occasions, and prolonged observation of the scar shows that it remains a thin line, and does not widen. Even after the incision has completely healed it is always advisable to keep the scar covered with gauze soaked in collodion for at least two months. In this way successful results are obtained.

Whatever operative treatment is adopted it must be remembered that it is only the first step, and completion of the cure depends upon the subsequent handling of the case. Practically the after-care resolves itself into the treatment of cervical scoliosis, and we fail to see how division of the sterno-mastoid, however thoroughly done, can enable one to dispense with or curtail the after-treatment.

It is also difficult to understand, from a mechanical point of view, in what way the total or partial extirpation of the sterno-mastoid differs from complete division.

Mikulicz[1] advocates this procedure, and states that after-treatment is not needed, while recurrence of the deformity is not met with. Other surgeons, however, have met with relapses, and it is certain that a large cicatrix must inevitably result. Complete extirpation is followed by paralysis in the area of distribution of the spinal accessory. Again, the natural contour of the neck is destroyed by removal of the sterno-mastoid, and the contraction of the resulting cicatricial mass leads to recurrence of the deformity, and has called for secondary excision. Further, there are the risks of injury to the large vessels of the neck. These considerations therefore induce the reflection that this procedure is not to be lightly undertaken.[2] It is certain that many good results have been obtained in partial resections, but in the writer's opinion the continuity of the muscle is just as much interrupted by a complete transverse section of it as by excision of half an inch or so of its lower portion. At the same time partial resection is a method well spoken of by surgeons of repute, such as Hoffa, Jaffe, Nové-Josserand.

Finally, plastic methods of lengthening the affected muscle have been carried out, such as oblique division and Bayer's Z-shaped method. Wullstein has combined partial resection of the affected muscle with shortening of the opposite one by pleating. This is unnecessarily severe.

After-Treatment.—The plan that the writer has adopted, after first seeing it employed by Mr. Longworth Wainwright at the Evelina Hospital, is as follows:—

The head is put into the over-corrected position, and the shoulder on the affected side is well drawn down. The parts are then fixed by the following arrangement in plaster of Paris:—A piece of house flannel is cut of such a shape as to cover the back down to the crests of the ilia, the posterior aspect, and sides of the neck, the vertex and sides of the head, reaching over the forehead to just above the supraorbital arches. A second piece, precisely similar, is cut and is soaked in moist plaster of Paris, and quickly adjusted to the back, neck, and head in the over-corrected position. A strip of flannel, of sufficient width, and soaked in plaster of Paris, is then placed round the neck, thus ensuring a correct fit of the first piece here, and it further acts as a collar for the support of the head in its new position. Whilst this is being done an assistant passes an

[1] *Centralbl. f. Chir.*, 1895, No. i.

[2] An instructive article on this subject is "Über die spät. Resultate der Resection des Kopfnickers beim muscularen Schiefhalse nach Mikulicz," *Zeitschr. f. orth. Chir.* Bd. ix., dealing with the late results in thirty-four cases.

ordinary roller bandage round the chest and abdomen, and round the head, neck, and shoulders, to keep the large piece of flannel soaked in plaster in position.

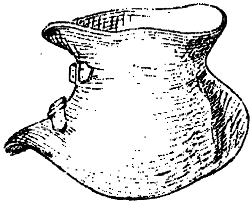


FIG. 47.—A Collar made of leather or poroplastic felt for the after-treatment of Congenital Torticollis.

When it is necessary to dress the wound, the bandage can be divided along the mid-line of the chest and neck, and the plaster cuirass temporarily removed and re-applied. After fourteen days the cuirass is replaced by a leather or poroplastic collar (Fig. 47), which is worn for four to six months. It is taken off daily, so that active and passive movements may be carried out, and a great deal of the success of the treatment depends upon the con-

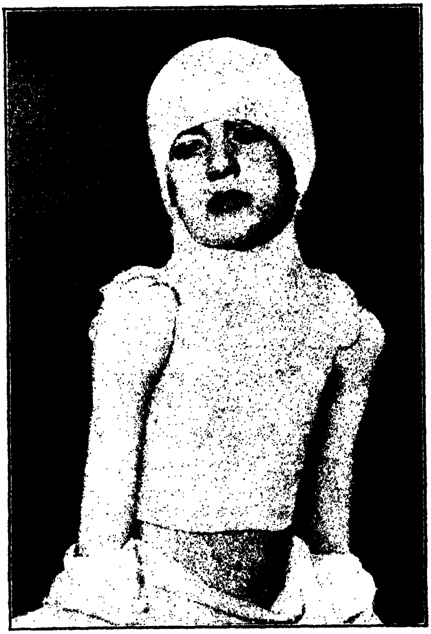


FIG. 48.—Left Torticollis, showing the method of fixing the head in the over-corrected position, after operation (Whitman).

scientiousness with which these movements are practised. Whitman's method of applying plaster is excellent (Fig. 48).

Among other methods of immediate after-treatment, Mr. Owen

maintains the head in place by sandbags until the wound has healed. When the patient can get up, he is directed to walk about with a bag of shot in the hand of the contracted side, and told to carry his head to the opposite side many times daily, practising in front of a mirror. At night he is advised to sleep on the affected side, with the head raised on a pillow. Bradford and Lovett use a metal apparatus (Figs. 49, 50).

Sayre's arrangement of an artificial sterno-mastoid (Fig. 51)

FIG. 49.—Support used in the Post-operative Treatment of Torticollis. Anterior view. (Bradford and Lovett.)

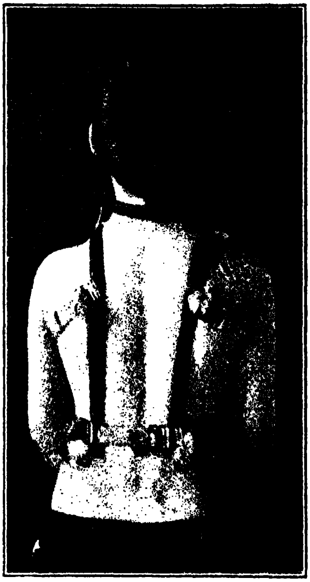


FIG. 50.—The Support Applied. Posterior view. (Bradford and Lovett.)

applied to the opposite side is a very useful adjunct for after-treatment in children.

Recurrence of the Deformity.—This is traceable to two causes, incompleteness in operating, and insufficient attention to after-treatment. The remedies are obvious.

Finally, the best results are obtained between the ages of two and twelve years.

Posterior Torticollis.—The usual congenital type which is associated with contraction of the sterno-mastoid is known as anterior torticollis. Occasionally the posterior cervical muscles are in fault, particularly the trapezius and levator anguli scapulæ. In some instances

this appears to be a variety of congenital elevation of the scapula. Frequently the deeper muscles—the complexus, splenius, trachelo-mastoid—are involved.

Treatment of these cases is difficult. So many muscles are implicated and are so deeply placed that section is inadvisable and dangerous. It is recommended that they be stretched by forcible manipulation under an anæsthetic, and the head maintained afterward in the corrected position. It is better to stretch the tissues moderately on several occasions than to employ what may prove a dangerous amount of force at one sitting.

FIG. 51.—Sayre's Arrangement for Elastic Traction after operation for Congenital Torticollis. The elastic band is placed on the sound side, and passes between the forehead and shoulder pieces. The elastic band is gradually shortened so as to obtain over-correction.

Occasionally the lateral structures of the neck are affected, and still more rarely both sterno-mastoids are shortened. The effect is curious. The chin points forwards, and the head is sunk into the neck.

ACQUIRED TORTICOLLIS

Displacement of the head from causes other than congenital is usually symptomatic. We deal with it here in order to make the clinical picture more complete.

As we have remarked, classification of the varieties of torticollis is difficult and not satisfactory. However, we present the following:—

A. Acute.

1. Myositis of the cervical muscles, usually rheumatic or gouty—the ordinary painful stiff neck.

2. Secondary to cellulitis of the neck arising from angina Ludovici, or the bursting of a suppurating tuberculous gland into the tissues of the neck.

B. Subacute.

Arising from the enlargement of glands in the neck or from infiltration of cellular tissue in tonsillitis, diphtheria, and measles. According to Whitman [1] this form also arises from irritation of the peripheral nerves in the naso-pharynx

[1] *Orth. Surg.* 3rd ed. p. 649.

or its neighbourhood. He fails, however, to give any evidence in support of this view.

C. Chronic.

1. Congenital—already dealt with.

2. Traumatism of the head and neck—unilateral dislocation of the lower cervical vertebræ causes permanent torticollis,[1] unless reduced.

3. Cicatrices of the skin and muscles.

4. Reflex irritation from caries of the spine. Here the movements are limited in all directions, while in the congenital form only those movements are curtailed in which the affected muscles are involved.

5. Neuralgia of the nerves of the brachial plexus.[2]

6. Scoliosis.

7. Astigmatism.[3]

8. Frequently repeated movements of the head, as in the case reported by Annandale,[4] of a girl aged 24 years, a weaver, who was obliged to move her head rapidly from one side to the other, but especially to the left. In her case the spasm developed in that side.

9. Rickets.

10. Paralysis of the spinal accessory nerve.

11. Spasmodic torticollis.

In fact, acquired torticollis is largely symptomatic, and its treatment naturally depends upon its cause. The acute and subacute forms usually disappear rapidly when the irritation ceases, but some cases of painful stiff-neck leave behind them a degree of permanent deformity.

[1] Tubby, *Encycl. Med.* vol. xi. p. 304. Also Walton, *Boston Med. and Surg. Jour.* cxlix. 17, 445.

[2] Döllinger, *Pesther med.-chir. Presse*, 1889, No. 48.

[3] Rédard, *Traité pratique de chir. orth.*; Bradford, *Trans. Amer. Orth. Assoc.* vol. i. 46; Stevens, *Arch. f. Ophthal.*, 1887.

[4] *Lancet*, 1879, vol i. p. 555.

CHAPTER III

CONGENITAL DEFORMITIES OF THE LIMBS

Congenital Absence of the Radius and of the Ulna—Club-hand—Congenital Contraction of the Fingers—Syndactylism or Webbed-fingers—Polydactylism—Suppression of the Fingers—Macrodactylism—Gigantism—Congenital Furrowing of the Limbs and Intra-uterine Amputation—Rudimentary or Absent Patella—Congenital Genu Recurvatum—Congenital Curvature of the Leg—Absence of the Tibia and Fibula—Congenital Hammer Toes and other Deformities of the Toes—Suppression of Segments of the Limbs—Congenital Contractions of the Limb.

CONGENITAL ABSENCE OF THE RADIUS

THIS condition is unusual. Reeves stated that at the Royal Orthopædic Hospital about three cases were seen annually. During the last eighteen years the author has met with eleven cases, one of which is figured here (Fig. 52). In an article on congenital absence of the radius, M'Curdy[1] has stated that there are 45 recorded cases. Whitman[2] adds that, according to Potel, 200 have been recorded. Recently Antonelli[3] collected and analysed 114 cases, of whom 60 per cent were males, 29 per cent females, and in the remainder the sex was not noted. It is evident that the condition is sufficiently frequent to warrant attention.

In slightly more than one-half of the number the malformation is unilateral, the right side being more often affected than the left, and in most cases the bone is completely absent. In the bilateral cases complete deficiency is the rule.

The whole extremity is somewhat atrophied, the forearm shortened, and in some cases very stunted. Generally the ulna is curved or bow-shaped, with the concavity towards the radial side.

[1] *Ann. of Surg.*, Jan. 1896, pp. 41-47; he also quotes Kronig, *B.M.J.*, March 10, 1894.

[2] *Orthopedic Surgery*, p. 180.

[3] *Zeitschr. f. orth. Chir.* Bd. xiv., 1905.

The hand is deviated, and may lie with its outer border on the forearm, the deviation being radio-palmar. On active contraction the angle formed by the radial side of the hand and forearm may be further diminished, so that the parts are actually in contact. Palpation and skiagraphy reveal the true nature of the case. The hand itself is small and atrophied, and absence of one or more metacarpal bones, either with or without the associated phalanges, is notice-

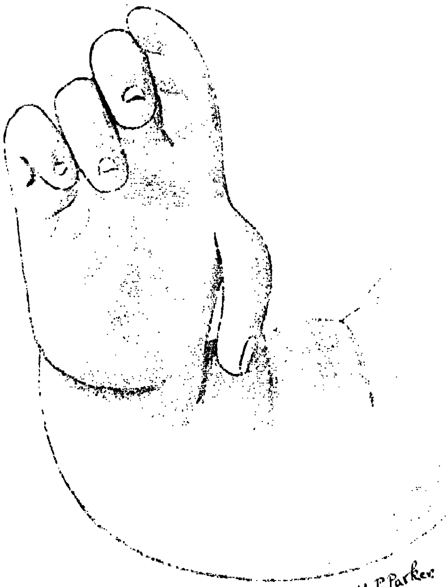


FIG. 52.—Radio-palmar variety of Congenital Club-Hand, with Partial Absence of the Radius and Complete Suppression of the First Metacarpal Bone.

FIG. 53.—The same case as in Fig. 52 after treatment for two years by malleable iron splints. An attempt has been made to form a Pseud-Arthrosis between the first phalanx of the thumb and the second metacarpal bone.

able. Occasionally the hand has been described as being perfectly developed. The thumb is usually rudimentary or absent (Figs. 52, 54). When present, it can often be made to slide up and down, as the metacarpal bone is wanting. In two cases the writer has seen the thumb, represented by its two phalanges, attached to the second metacarpal bone by membrane and skin, the first metacarpal bone being absent. In one of these cases an attempt was made to join the first phalanx of the

thumb to the second metacarpal bone by an arthrodesis, but the thumb remained functionless afterwards (Fig. 53). The grasp of the hand is as a rule very feeble.

In the case of partial defect, when the lower end of the radius is present, the displacement of the hand is less marked.

Observers are not agreed as to which portion of the radius is most frequently wanting, but in the cases seen by the author the upper epiphysis has been present, while the shaft and lower epiphysis have been absent. With appropriate treatment, and after watching the cases for over twelve years, some development of the shaft of the radius has been seen to take place.

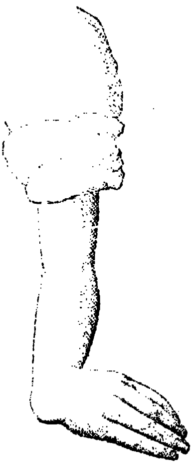


FIG. 54.—Congenital Absence of the Radius and Thumb. Radio-dorsal variety of Club-Hand. (Rédard.)

Frequently other developmental malformations (Figs. 55, 56, 57) and abnormalities exist, such as congenital hydrocephalus, ectopia vesicæ, and horse-shoe kidney. Occasionally the viscera are so abnormally developed that the child is born dead, or life speedily becomes extinct. One commonly recorded defect is absence of the ventricular septum of the heart.

Apart, however, from such palpable causes of enfeebled vitality, it is well known that the outlook is poor in even uncomplicated radial defect. All observers agree that these patients show a general want of resistance, and usually die young. Kümmel is convinced that the prognosis is gloomy. Several cases in adults, however, have been recorded, and 27 years is the most advanced age which has as yet been noted. In one instance a fairly useful hand was present, and the patient was able to write.

Ætiology.—Henry Ling Taylor[1] sums up two of the theories, generally advocated:—

"The first theory assimilates the condition to the archipterygeal or primitive fin theory of Gegenbauer. According to him the arm consists of a stem and four rays. The first ray comprises the radio-scaphoid, trapezium, the first metacarpal bone, and two phalanges. According to this theory the bony defect is always a suppression in regular order from above downwards of one or more

[1] *Trans. Amer. Orth. Ass.* vol. x. p. 174, 1897.

PLATE VIII.

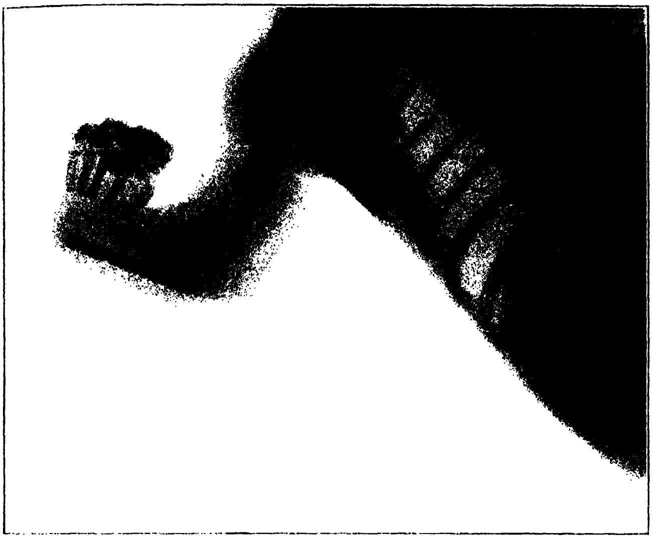


FIG. 1.

Skiagram of the Upper Extremity of a child, with Complete Absence of the Radius and Club Hand.

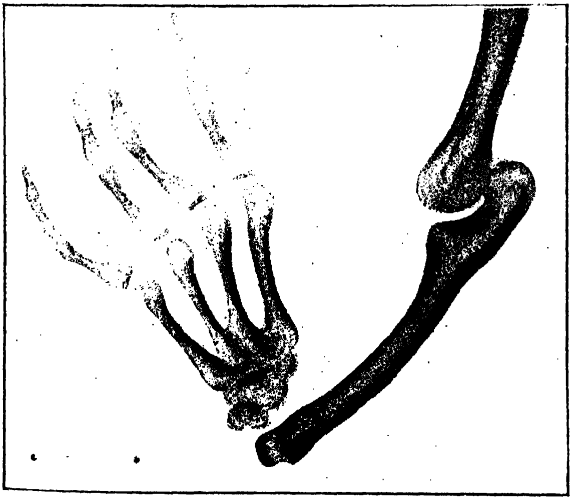


FIG. 2.

Diagram of Congenital Absence of Radius and the Bones of the Thumb (Weigel).

To face page 78.

rays, and nervous influence is rather blindly invoked as a causative factor."

As this theory does not explain those cases with a well-developed thumb, its advocates assume that they are not examples of an absent radius properly speaking, but cases of fusion of the radius with the ulna.

"The second theory ascribes the anomalies to a mechanical cause, namely, the pressure of the amnion and deficiency of fluid at the time of development of the arms, namely, about the fifth week." Though the cause of this assumed constriction is imperfectly known, the theory has some strong points in its favour, and particularly those afforded by the analogous condition, absence of the fibula. The tibia is the homologue of the radius, but the fibula is analogous in position, and—like the radius—is much more exposed to pressure from outside.

As a matter of fact, absence of the radius or fibula, though rare, is more common than absence of the ulna or tibia. In cases of absence of the fibula, the fifth digit is usually lacking, and the tibia is shortened and bent. Very interesting is the appearance of dimples, furrows, or scar-like marks, so frequently found in proximity to the projecting angle of the tibia, and there is good reason to believe that these are caused by the separation of amniotic adhesions. Similar marks have been noted in defect of the radius, *e.g.* over the styloid process of the ulna (Antonelli); about half an inch above the end of the ulna (H. L. Taylor); over the distal end of the ulna and on the styloid process (Kirmisson). In a case of Rédard's the linear depression or scar on the skin occupied the whole internal aspect of the forearm. Circular constricting bands of the skin of the forearm are also seen.

The second theory is the one more generally favoured. At the same time, apart from the difficulty of conceiving how such a regular and typical deformity can be caused, and recognising the fact that congenital anomalies are so frequently noted elsewhere, all of which cannot be ascribed to amniotic bands, the conception is rendered still more difficult by the occurrence of defect of the radius associated with polydactylism in more than one case.[1] We shall have occasion to point out elsewhere that the supporters of the

[1] Kirmisson, Sainton, and Parker have described two cases of congenital defect of the radius, in which the thumb was strikingly developed, and possessed three phalanges. In Kast's case the thumb was cleft. Schmidt also records a supernumerary thumb, and Tschmarke seven fingers on the affected extremity.

mechanical and amniotic theories are prepared to meet even these points, but to most people the explanation will appear far-fetched.[1]

Heredity is not a marked feature. Bouvier recorded occurrence of the deformity in a father and his children. It has been more frequently seen in brothers and sisters. Thus Blencke[2] records a case in which the deformity occurred in the first, second, seventh, and ninth children of a family.

Treatment.—The following is a brief summary of what has hitherto been attempted :—

1. Tenotomy and division of resistant structures on the radial side of the forearm.
2. Simple or cuneiform osteotomy of the ulna, followed by over-correction (Hoffa, Romano).[3]
3. Excision of one or more bones of the carpus, and the insertion of the ulna into the cavity. R. H. Sayre and Roswell Park,[4] in carrying out this operation, sharpened the end of the ulna after the fashion of a stake, attempting, as it were, to impale the carpus.
4. Bardenheuer's proceeding.—The ulna is split through its mid-line into a radial and an ulnar section. They are separated by allowing the carpal bones to come up between them. By means of an ivory peg on each side the ends of the ulna are fixed to the carpus. A plaster bandage is put on, and left for four weeks. I have performed this operation thrice and with success. Instead of using an ivory peg I have stitched the parts in place with silkworm-gut.
5. Leroy M'Curdy, finding Bardenheuer's operation impossible on account of the shortening of the soft structures, which rendered futile any attempt to shift the end of the ulna to the centre of the carpus except by a virtual amputation of the forearm, performed the following operation in the case of a female aged five months :—

"The ulna was severed at a point where the free end of the upper fragment could be brought to the semilunar bone. An

[1] On this point see Blanchard, *Sur le rôle de l'amnion dans les malformations congénitales*, Paris, 1902.

[2] *Rev. d'orth.*, Nov. 1905, p. 562.

[3] See also P. Rédard, *Trans. Amer. Orth. Ass.* vol. xiv., 1901, and full report of a case with interesting family history by C. E. Thompson, *Trans. Amer. Orth. Ass.* vol. ix. p. 96.

[4] *Trans. Amer. Orth. Ass.* vol. xiv., 1901, p. 145.

incision was made obliquely across the forearm, beginning upon the dorsum, and passing upward and around to the flexor aspect, the object being to allow the structures to slide upon each other, and then to be sutured in the corrected position, thus avoiding the gap that would otherwise be left after a cross section. The tendons on the radial side were divided, and the ulna severed at the point mentioned above, the semilunar bone being connected and drilled; after drilling the ulna, these bones were adjusted with silkworm gut."

The result appears to have been successful.

6. Antonelli points out that procedures interfering with carpal joints are not ideal on account of the subsequent fixation; and further, that tenotomies in an already weakened part ought to be avoided. He claims to have split the ulna longitudinally from the wrist to near its cubital end; to have separated the radius thus formed by the interposition of neighbouring muscles. He then rectified by manipulation the bend in the ulna, and attached the lower end of the newly made radius in position to the ulna and carpus with wire. He avoided tenotomy of the shortened tendons by Z-shaped lengthening.

This operation was performed on both sides in an infant aged five months, and with a result satisfactory to Antonelli.

These splitting procedures are based upon the fact, which should have been mentioned previously, that when the radius is entirely or partially deficient congenitally, the ulna is much thickened, especially at its lower end, and extends for two-thirds of the distance transversely across the carpus. The limited experience of the writer in these splitting operations has taught him that while the club-hand deformity is rectified, yet pronation and supination are sacrificed to a considerable extent. The net result, however, is a gain to the hand, so far as its usefulness is concerned.

Congenital Absence of the Ulna

This condition is more rare than absence of the radius, but Kümmel and Hoffmann mention a case.[1] It has been found to be hereditary by Robert.

The hand deviates to the ulnar side, but it is more useful than when the radius is deficient. As a rule the third, fourth, and fifth fingers are suppressed.

[1] *Trans. Amer. Orth. Ass.* vol. xiii. p. 96.

Club-Hand

Normally the hand is the direct prolongation of the fore-arm, that is, the axes of the forearm and hand coincide. When this relation is disturbed the condition may be described as club-hand,

Fig. 55.

Fig. 56.

Anterior and posterior views of a child affected with left Club-Hand, Congenital Contraction of Hips and Knees, and double Talipes Equino-Varus.

thus bringing it into line with the definition of club-foot. As thus defined, club-hand may be:—

A. *Congenital.*

1. No defect or marked abnormality of the bones being present.

   (*a*) Cases strictly analogous to congenital club-foot or contractural. These are excessively rare.

   (*b*) Cases where the deviation depends on congenital dislocation of the wrist; likewise very rare.

2. Deviation associated with defect of one of the bones of the fore-arm.

   (*a*) Partial.

   (*b*) Complete.

B. *Acquired.*

1. Various paralytic and neuro-muscular lesions.
2. Deviations due to disease of the wrist-joint and carpus.
3. Those dependent on acquired curvature of the bones of the forearm.
4. Madelung's subluxation. See vol. i. p. 301.

While congenital club-foot, meaning congenital talipes equino-varus, due to contraction of the muscles and tendons, is common, an analogous condition of the hand is extremely rare. Conversely, congenital club-foot, due to absence of bone, is rare, but in the hand absence of bones is the most usual cause. We have already mentioned the effects of absence of the radius or ulna on the hand.

Fig. 57.—Double Club-Hand, and Bilateral Talipes Equino-Varus.

Bouvier was the first to publish any considerable contribution to the subject. Of his 24 cases, 8 were due to contracture, without osseous defect. Hoffa found references to 12 cases, Zengerly to 19, and E. Rosenkranz [1] to 57.

Some valuable remarks, bearing on the ætiology, will be found in an article by G. R. Elliott,[2] on a case of multiple congenital deformities. Kirmisson, in his work on "Congenital Deformities," devotes considerable attention to the subject Other examples have been carefully noted in cases of extreme monstrosity, but as a rule no detailed description has been given the observer's vision being focused on graver anomalies elsewhere.

In order of frequency, the deviations observed were: ulnar-palmar, palmar, radio-palmar, pure ulnar, pure dorsal, and radio-dorsal, and generally the affection is bilateral. In the majority of cases abnormalities existed elsewhere, and have been noted in all

[1] "Über kongenitale Kontrakturen der oberen Extremitäten," *Zeitschr. f. orth. Chir.* Bd. xiv., 1905, Heft 1.

[2] *Trans. Amer. Orth. Assoc.* vol. xii., 1899.

cases except ten. The co-existing abnormality most frequently met with is *pes varus*. In Whitman's work on *Deformities* (Figs. 737 and 738) the association of hand and foot deformity is well depicted. Three times has club-hand from muscular and tendinous contraction on one side, with radius defect on the other side, been noted (Prestall, Cruveilhier, Birnbacher). Polydactylism and various congenital dislocations, atresia ani, malformations of the genitals, and other anomalies have been seen, and are of importance from the ætiological standpoint.

FIG. 58.—Congenital Contraction of the little finger of the left hand, in a girl aged 15 years.

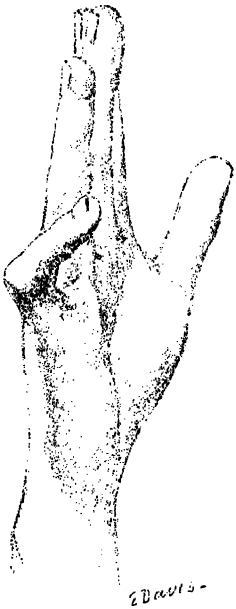


FIG. 59.—A similar Deformity in the right hand of the same patient as in Fig. 58.

A detailed description of the symptoms is unnecessary, but a skiagram should always be taken to ascertain which, if any, portion of bone is wanting.

As to the causation, the theories can only be shortly referred to here. Three are worthy of consideration. These are :—(1) A neurogenetic origin, due to abnormality of the nervous system and intra-

uterine disease; (2) Intra-uterine malposition; (3) A defect of development.

The weight of evidence appears to be in favour of a neuro-genetic origin, but in a few cases there seems to be valid evidence in favour of intra-uterine malposition. As to the third cause little is known.

The treatment should be conducted on general orthopædic principles. If operative procedures are attempted, they should be carried out on the lines described in congenital absence of the radius (p. 80).

CONGENITAL CONTRACTION OF THE FINGERS

FIG. 60.—Congenital Contraction of the ring and little fingers in a boy aged 5 years. The palm is entirely free from contraction.

This is quite distinct from contraction of the palmar fascia or Dupuytren's deformity. Congenital contraction is met with as the only deformity, or it may be a detail of some graver abnormality, such as club-hand, syndactylism, and cleft-hand. The thumb,[1] or one or more (Figs. 58, 59, 60) of the fingers, may be affected, and the deviation is palmar, dorsal, or lateral.[2] If the contraction is marked, there is more or less luxation of the affected joint, which is usually the first interphalangeal, and this is sometimes described as congenital dislocation or subluxation of the finger. An exception must be made to this in the case of contractions dependent upon,

[1] "Pouce-bot" or "Klumpdaumen" are terms sometimes used by Continental writers to describe an opposed and adducted position of the thumb. On looking at the hand from the dorsal aspect, the thumb seems lacking. In these cases it may be possible for the patient to hold light articles, by pressing the index-finger against the dorsal surface of the thumb.

[2] "Klumpfinger," "Doigt-bot," "digitus valgus et varus," are all objectionable terms. In these rare deformities it is better to use descriptive terminology, even if it is cumbrous: thus, congenital lateral (radial or ulnar) deviation of the index-finger at the first interphalangeal joint.

or at all events accompanied by, alterations in the direction of the joint surfaces.[1]

Generally the affection is limited to the fifth finger, but at times

FIG. 61.

FIG. 62.

Congenital contraction of the little finger of the right hand, and of the ring and little fingers of the left hand, in an infant, aged 2 months.

the ring-finger and all the fingers are contracted.[2] Congenital contraction or palmar flexion of the first interphalangeal joint of the little finger is often hereditary. Further, it is frequently associated with congenital hammer-toe (Fig. 66), and in that event the second toe is often affected in both feet.[3] Some congenital contraction of the little finger is not at all uncommon, particularly in women,[4] and it is only

FIG. 63.—A Dorsal view of the left hand in Fig. 62, showing the Hyper-extension of the First Phalanges in Congenital Contraction of the fingers.

[1] Kölliker, "Digitus Valgus et Varus," Joachimstal's *Handb.* He describes a condition of obliquity of the head of the metacarpal bone, leading to abduction of the little finger, but inasmuch as the joint surfaces were still in contact no dislocation was present.

[2] Tubby, *Deformities*, 1st edition, figs. 105, 106, 108, 110, 111.

[3] *Ibid.*, p. 219.

[4] William Adams, *Contraction of the Fingers and Hammer-toe*, 2nd edition, p. 96. Churchill, London.

when it becomes troublesome that it comes under the notice of the surgeon. Adams states that no deviation is observed in the little finger at the period of birth. On this point it is permissible to differ from him, and the author has seen and figured cases which prove the contrary.

The affection progresses through three stages. In the first, there are seen some flexion of the second and third phalanges of the little finger, and some inclination of them outwards towards the median line of the hand. No contracted bands of fasciæ can be

FIG. 64.

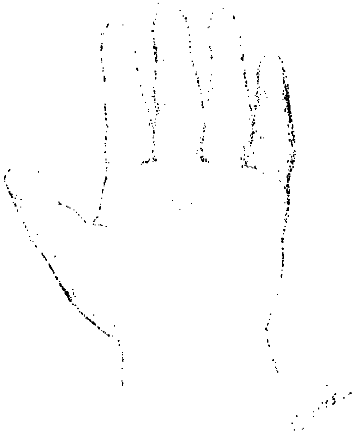


FIG. 65.

The condition of the fingers in Figs. 61 and 62, after treatment by operation and manipulation.

felt, nor is there any shortening of the skin on the palmar aspect of the finger. The flexed phalanges can in many cases be restored by gentle manipulations, but they drop so soon as the extending force is removed. In the second stage, according to Adams, the flexion of the second and third phalanges is increased and permanent, and the first phalanx is hyper-extended.[1] Any attempt to straighten the finger is resisted by the contracted skin and fascia, and by the shortened lateral ligaments of the articulations. This stage is reached at about the seventh to the tenth year. In the third stage, not only is the deformity aggravated in the finger originally affected, but the other digits begin to contract, although the palmar fascia is

[1] On this point the author differs from Adams. The first phalanx is hyper-extended, the second is flexed, and the third is extended, and he is supported in this contention by Joachimstal's description and figures.

never involved, as in Dupuytren's contraction. In the congenital form, according to Adams, a central longitudinal band of contracted fascia makes its appearance on the flexor aspect of the phalanges. This band is not a thickening of the digital prolongations of the palmar fascia, which are situated more on the lateral aspect of the phalanges. Occasionally in the third stage the three phalanges are hyper-extended instead of flexed.

With reference to the ætiology, little is known beyond the facts that the affection is both congenital and hereditary. A shortening

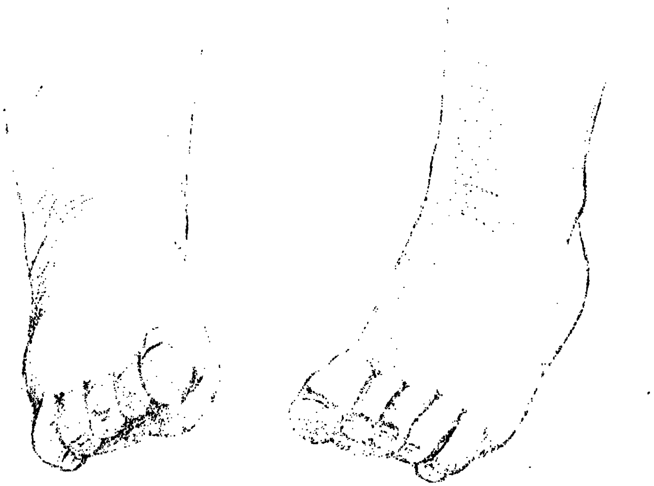


FIG. 66.—The feet of the infant whose hands are seen in Figs. 61, 62, p. 86. The little toes are congenitally contracted.

of the flexor tendons without paralysis of the extensor,[1] contraction of the skin,[2] ligamentous contraction of the flexor aspect of the affected joints,[3] have been suggested by various authors, amongst them the late William Anderson.[4] The opinion is expressed that the chief agent in causation is an insufficient growth of the lateral ligaments of the phalangeal joints, their growth not proceeding *pari passu* with that of the bones.

The only account of a dissection which I have come across is

[1] Gerhardt's *Handb. der Kinderkrankheiten*.

[2] Lonsdale, *Lancet*, September 1855; Hester, *Med. Times*, March 1851.

[3] Annandale, *Malformations, Diseases, and Injuries of the Fingers and Toes*, Edinburgh, 1865, p. 65.

[4] "Lectures on Contraction of the Fingers and Toes," *Lancet*, July 1891.

that by Mr. C. B. Lockwood.[1] He states that "the band in question consisted of a thickening of the digital fascia opposite the flexor aspect of the proximal interphalangeal joint. Excepting that it was thickened and shortened, the finger was perfectly natural." Still, as already observed, in early cases no band at all can be felt.[2]

Usually the affection is, as already stated, most marked in the little finger, and diminishes towards the radial side, but exceptions to this have been recorded. Thus Majer[3] recorded contraction in the little and ring fingers of both hands, and Annandale[4] describes bilateral contraction of the index and little fingers.

Diagnosis.—1. From Dupuytren's contraction. The following table gives the distinctive points:—

	Congenital Contraction.	*Dupuytren's Contraction.*
Age of onset .	Infancy and childhood.	Adult life.
Sex . . .	More often female.	More often male.
Point of origin .	Fascia of fingers.	Fascia of palm.
Parts affected in fingers	Central portion of palmar prolongation.	Lateral portion of palmar prolongation.
Position of phalanges	First is hyper-extended, the second is flexed, and the third is extended.	First and second flexed, the third is generally extended.

2. From contractions of the fascia and tendons (Figs. 67, 68) other than Dupuytren's. This is generally made clear by a history of injury, of suppuration, of some nerve-lesion, or of arthritis deformans. Occasionally scars will be found about the forearms, wrist, or fingers.

Treatment.—In the first stage it is sufficient to straighten the affected fingers by frequent passive movements, and to fasten a small malleable iron splint to the back of the hand and to the finger, so that the latter is retained in a fully extended position. In suitable cases a little appliance made by the instrument-maker, Matthieu of Paris,[5] may be used. This consists of a splint adjusted to the palmar surface of the metacarpal bone of the little finger, with the flange turned up around the ulnar border of the hand. To the flange an adjustable spring is attached, which draws backwards a plate bearing on the back of the first interphalangeal joint. Any appliance used should be removed three times daily, and the fingers passively exercised. If all these means prove insufficient,

[1] *Path. Soc. Trans.*, 1886.
[2] Fort, *Des difformités congénitales et acquises des doigts*, Thèse, Paris, 1869, p. 60.
[3] Hoffman's *Jour. f. Kinderkrankheiten*, Band lviii.
[4] *Loc. sup. cit.*
[5] See Kolliker's figure in Joachimstal's *Handbuch*.

division of the shortened bands of fascia is called for,[1] the finger being put up after the operation in full extension on a small malleable iron splint.

In performing this little operation, the fascia knife is passed between the skin and the band, and the latter cut transversely. It is always advisable, after inserting the knife beneath the skin, to pass it up and down for a short distance, so as to sever the fine processes which pass from the fascia to the skin. As a rule about three punctures are required to each phalanx.

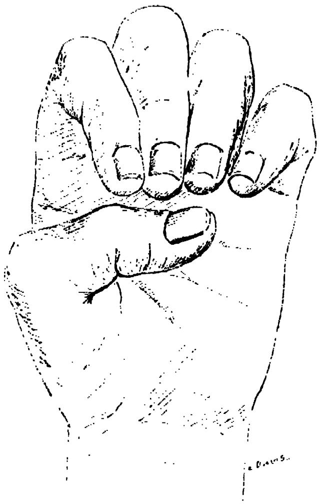


FIG. 67.—Contraction of the Digits, said to have existed from birth.

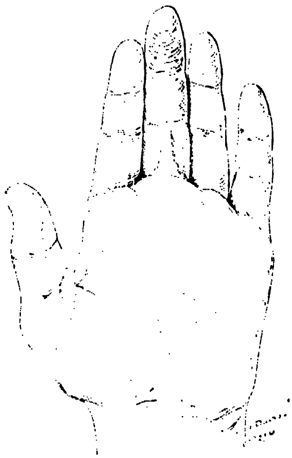


FIG. 68. Front view of the Hand in Fig. 67 after section of all the flexor tendons at the wrist. Free movements of the fingers followed.

Vogt[2] recommends a procedure which has also been carried out by Hester,[3] making a V-shaped incision, the point of the V being towards the root of the finger, through the contracted structures, and uniting it up again in Y-shape. Coudray[4] recommends resection at the first interphalangeal joint.

Unfortunately these cases show a strong tendency to relapse, and it is well to warn the patient that after a finger has been straightened, a long course of mechanical treatment will be necessary

[1] Cf. *Deformities*, 1st edition, p. 243.

[2] "Die chirurgischen Krankheiten der oberen Extremitäten," *Deutsch. Chir.* Lief. lxiv. S. 15.

[3] *Loc. sup. cit.*

[4] "Traitement de la flexion du petit doigt par la résection," *Sem. méd.*, 1895, No. xlii.

to maintain the improvement. For this purpose an apparatus similar to that used after the operation for Dupuytren's contraction (Fig. 602, p. 819) may be worn day and night for three months in cases in the second stage, and at night for a further period of three months in cases in the third stage. My colleague, Mr. Muirhead Little,[1] has tried forcible extension in a case, but the affected finger showed a marked tendency to re-contract; this he hoped to combat by a simple splint he had designed.

In inveterate cases, and in people who obtain their living by manual labour, the propriety of amputating the offending digit ought to be discussed with the patient. It may be added that tenotomy has not proved successful in late cases, as this operation, when done in the fingers, is liable to be followed by non-union.

Congenital Deformities of the Hands and Fingers

WEBBED FINGERS

Synonyms—*Syndactylism*; *Syndactyly*: *Syndactylia fibrosa, ossea.*

In the condition known as webbed fingers there is more or less close union of contiguous digits. Three varieties exist:—(*a*) Those in which union is by skin only; (*b*) by skin and fibrous tissue (Fig. 69); (*c*) the bones are more or less fused together.

FIG. 69.—A severe example of Syndactylism. On the right hand there are two supernumerary thumbs, the index finger is partially joined to the middle finger, and the soft tissues of the middle, ring, and little fingers are fused. On the left hand a Supernumerary Thumb is present, and a wide cleft exists between the index and middle fingers, whilst the soft tissues of the middle, ring, and index fingers are fused.

Unfortunately, from the point of view of treatment the actual condition is not so simple and straightforward as this classification suggests. Thus a syndactylia cutanea, in which two fingers are enveloped in a common sheath of skin, and have a common nail, is often a more difficult condition to remedy than a union including fibrous elements, but not so extensive in character. The syndactyly is often associated with other abnormalities, such as polydactyly and

[1] *International Med. Mag.*, May 1894: "Remarks on Congenital Contractions of the Fingers and their Treatment by Forcible Extension."

ectrodactyly. An interesting variety is that in which the bases of the fingers are separated, but distally they are united. This is sometimes spoken of as lattice-like or "gitterförmige."[1] Such cases afford strong reasons for assuming a mechanical origin. It is possible that the fingers have developed separately, and then later for some reason they have been pressed so closely together that adhesion has taken place. This assumption is increased when we notice that sometimes at the point of union the last phalanx of one finger overlies that of the other.[2]

The affected fingers are usually those on the inner side of the hand. Fusion of the thumb and index finger is very rare, but an excellent example is recorded by Roucayrol.[3] Klaussner[4] discusses and pictures an interesting case, which is either syndactylia of the index finger and a thumb of three phalanges; or is syndactylism of a double index finger, with suppression of the thumb. Roucayrol's case is all the more interesting because the ulnar fingers are normal; whereas in most of the rare cases recorded, in which the thumb is involved, the condition is associated with close union of the fingers.[5]

Roucayrol thus sums up the leading theories as to causation:—

1. Lesions of the fœtal nervous system. (Jules Guérin.)
2. External pressure and traumatism during pregnancy. (Cruveilhier.)
3. Embryonic amniotic adhesions. (Lannelongue.)
4. Amniotic loops or bridles. (Dareste.)
5. Reversion to early condition. (Darwin.)

Goldman[6] says syndactylism may be rightly regarded as an arrest of development, since, during fœtal life, the fingers are bound together for a time by webs of varying extent. The thumb almost always remains free, and in most instances two fingers only, usually the third and fourth, are bound together. These facts can at once be explained by referring to what takes place in the development of the hand. It is known that the thumb becomes detached from the fingers about the seventy-fifth day of fœtal life, whilst the four

[1] Klaussner, *Über Missbildungen der menschlichen Gliedmassen*, Wiesbaden, 1900. p. 66.

[2] Cf. Klaussner, *op. cit.* fig. p. 60, and skiagram, p. 61. From these illustrations we cannot resist the impression that fingers which were developed separately have been bound together by a constricting band about the level of the first interphalangeal joint.

[3] *Rev. d'orth.* Jan. 1905, with fig. and skiagrams. [4] *Op. cit.* pp. 29, 30.

[5] Cf. Rasch, *Beiträge zur klin. Chir.* Bd. xviii. Heft 2, 1897.

[6] *Beiträge f. klin. Chir.*, 1891.

fingers remain bound together for a much longer time. It will therefore be evident that the disturbing cause must arise after the thumb has become distinct. The subsequent separation of each finger does not take place simultaneously, but in the following way, as is seen in the larvæ of the triton and proteus. The forefinger, after the thumb has separated, sends off a branch, which constitutes the middle finger, and from this main branch secondary branches are sent off which form the ring and little fingers. We have therefore to suppose that some cause, the exact nature of which we are unable to determine, delays the separation of the branches.

Like many peculiar hand and foot conditions, syndactyly is markedly hereditary. Audebert[1] records its transmission through four generations, and Ebstein[2] through five, the transmission being through both males and females. Such examples are very instructive with regard to the Mendelian views of heredity, because the deformity is one which is readily recognised, and a family record is easily obtained. In Roucayrol's case a syndactylous woman had married a man who was no relation and without any history of deformity, and she bore normal children. Subsequently she married a cousin, who was also normally formed, but she bore three deformed males and two normal females.

Treatment.—It is rarely that in the osseous variety anything can be done, unless the fusion is limited to the last phalanges, as in the lattice-like deformity. In this case it is easy to split the terminal phalanges by a pair of sharp bone forceps, after dividing the soft tissues, and when healing of the parts has taken place the result is good. In some instances the synostosis is limited to the first phalanges, the remainder of the fingers being united by soft tissues. Then the first phalanges should be split, and the operation completed by one of the plastic methods which will be mentioned shortly.

Simple division of the web almost always fails either partially or entirely, because the fingers cannot be kept from re-uniting, cicatrisation proceeding from the cleft of the fingers downwards. In order to prevent this the raw surfaces at the base of the cleft must be covered by epidermis.

Many methods have been employed to accomplish this purpose. Some of them are the following:—

[1] "Syndactyle et polydactyle héréditaire," *Soc. d'Anat. et de Physiol. de Bordeaux*, 1896, No. 10.

[2] *Virchow's Arch.* Bd. cxliii. Heft 2, 1898.

1. After dividing the web, the dorsal and palmar edges at the base of the cleft may be sutured together. This is not always possible, because the fingers are so closely placed together at their bases, and the thickness of fibrous and other tissues is such that sufficient skin cannot be obtained to cover the raw surface.

2. The clefts may be lined with a flap, cut as in Zeller's operation (Fig. 70). A triangular flap, AEB, is reflected from the dorsum of the fingers. The web is then divided along CD, and the division prolonged as far towards the palm as is necessary. The flap, AEB, is then drawn forwards through the cleft, and its tip fixed to the raw surface in the palm. The remainder of the raw surface is then allowed to granulate over.

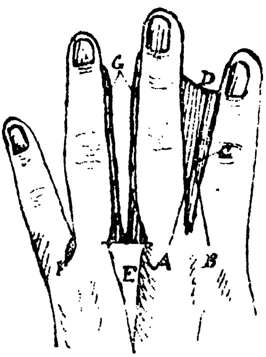


FIG. 70.—Zeller's operation for Syndactyly. For explanation see text.

3. Another method of lining the cleft is Félizet's procedure. A quadrilateral dorsal flap is cut, with its base attached towards the tips of the fingers. A similar flap is cut in the palm, with its base pointing towards the wrist. A cleft is made at the base of the web, and the two flaps are passed through, the dorsal one from behind forwards, and the palmar from before backwards (Fig. 74), and the web is subsequently divided. The details of the operation are best explained by the accompanying diagrams (Figs. 71, 72, 73, 74).

4. The author has devised and practised the following operation, which consists essentially of establishing a fistula completely lined with epithelium at the base of the web, by keeping a glass rod immovably fixed there during the healing process. Instead of using quadrilateral flaps, as in Félizet's procedure, triangular flaps (Fig. 75, A and B) are made in the situation of the base of the normal interdigital cleft. The palmar flap, A, has its apex upwards, and the dorsal flap, B, downwards. The dorsal flap is higher on the hand than the palmar, because of the natural obliquity of the interdigital cleft; and the flaps are cut long, as it is found that a considerable amount of tissue is required to cover completely the surfaces of the foramen about to be made. In making the foramen at the base of the web, a mere incision is insufficient. The soft tissues must be cut away until a clear opening, at least one-third of an inch in diameter, is formed.

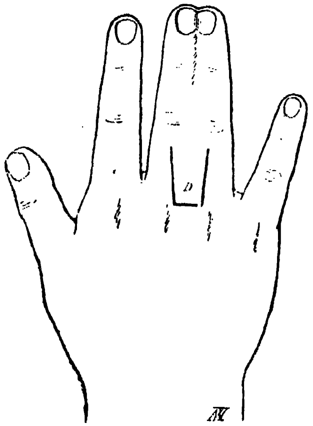


FIG. 71.—Félizet's operation for Syndactyly, showing the position of the dorsal flap of skin and subcutaneous tissues (from Berger and Banzet).

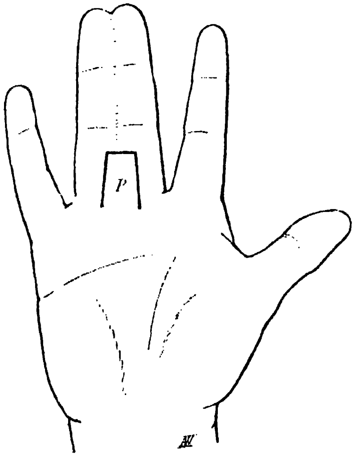


FIG. 72.—Félizet's operation for Syndactyly, showing the position of the palmar flap, which is cut in the opposite direction to the dorsal flap (from Berger and Banzet).

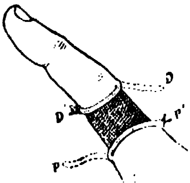


FIG. 73. The third stage in Félizet's operation. A large and sufficient opening having been made in the deeper tissues uniting the fingers, the dorsal flap of skin D and the palmar flap P are sutured in the gap at D' and P', so that their cutaneous surfaces are opposed (see Fig. 74) (from Berger and Banzet).

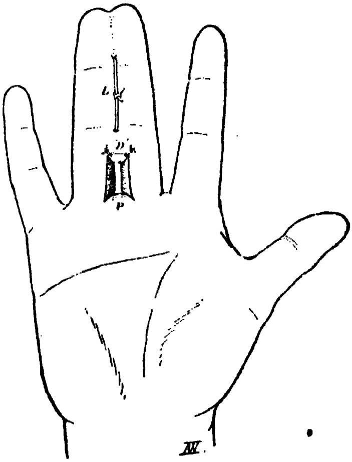


FIG. 74.—Félizet's operation. The cutaneous flaps P and D are fixed in the gap with their cutaneous surfaces opposed at P and D'; and an elastic ligature L has been passed through the remainder of the web so as to destroy it gradually (from Berger and Banzet).

The next step, after arrest of hæmorrhage by pressure, and not by ligatures, as the latter interfere with the healing process, is to draw each flap through the foramen, adjust them carefully, with their epithelial surfaces opposed, looking towards the centre of the foramen, and fix them thus: the tip of the palmar flap is sutured to the lower edge of the dorsal wound, and the tip of the dorsal flap is fixed to the upper edge of the palmar wound. Fine silk-

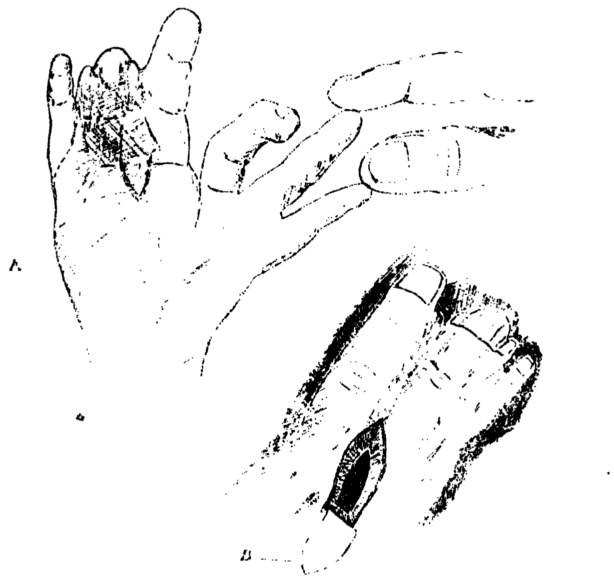


FIG. 75.—To illustrate the author's operation for Webbed Fingers. At A, a triangular flap is cut on the palmar surface with its apex upwards. At B, a second flap is cut on the dorsal surface with its apex downwards. The flaps consist of skin and subcutaneous tissue. The deeper tissues of the web within the limits of the flap are excised, and each flap is passed through the gap and its tip secured by sutures. For this illustration (Figs. 76, 78, 79) the author is indebted to his friend and colleague, Mr. E. Rock Carling.

worm gut is found to be the best material for sutures. The flaps should be very carefully adjusted within the foramen so as to lie snugly. Even then the foramen has an invincible tendency to close unless it is kept distended. For this purpose a glass rod, not less than one-third of an inch in diameter, is held immovably in the foramen until it is completely healed (Fig. 76). It is found in practice that any rod or pin passed through the base of the web works its way downwards towards the tips of the fingers, the cause being the formation of granulations above the foreign body, and

sloughing below it. The rod must therefore be held firmly. I have devised an apparatus (Fig. 77). It consists of a closely-fitting metal wristlet A, carrying two metal arms B and B[1], which hold the glass rod C in place by means of two screws D and D[1] (Fig. 78). The rod shows no tendency to shift downward, and can be removed for dressing the wound and then replaced.

There are some points of importance to be noted now and later. The operation and treatment must be completely aseptic from first

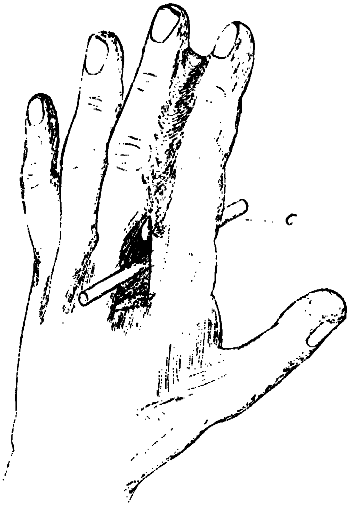


FIG. 76.—A Glass Rod, C, is passed obliquely through the gap, after the skin-flaps have been sutured so as to line it.

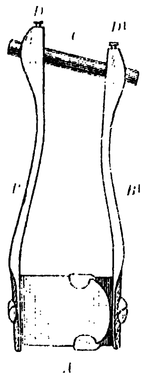


FIG. 77.—The author's Apparatus, designed to keep the Glass Rod in place, and prevent it being forced by granulations towards the tips of the fingers. At A is a metal band which encircles the wrist. *B* and *B*[1] are metal arms, *B* for the palmar and *B*[1] for the dorsal surface, carrying the glass rod *C* which is held by the screws *D* and *D*[1]. The glass rod should be more oblique. (From a drawing kindly made by Mr. B. White, of Westminster Hospital.)

to last, and the formation of granulation tissue avoided as much as possible. Primary union is essential. The exact position of the metacarpo-phalangeal joint is noted, and the direction of the normal web observed. It is very oblique from before backwards and not straight, therefore the perforation through the web is made from behind downward and forward in an oblique direction and commences on the dorsum, a little above the level of the metacarpo-phalangeal joint. In cutting the triangular flaps the direction of the foramen and the extent of the raw surfaces to be covered must be borne in mind. Hæmorrhage is best arrested by pressure, and

not by ligatures. The parts must be kept at rest, and the forearm and hand fixed in a malleable iron splint until healing is complete, and in the case of children it is well to secure the limb to the trunk. Lastly, if the operation is aseptic, very few dressings will be required, and the fewer the better.

When a complete and perfectly lined fistula has been established,

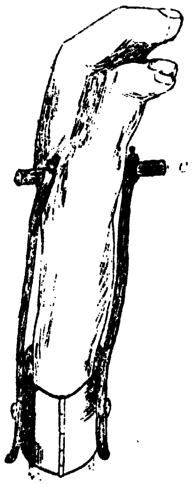


FIG. 78.—Side view of the hand with the apparatus and glass rod *C* in place. The rod should be placed more obliquely from before backwards, so as to follow the natural line of the inter-digital cleft.

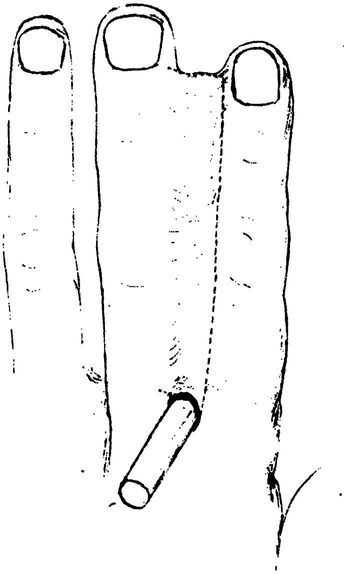


FIG. 79.—The final stage of the author's operation for Webbed Fingers. A Fistula, completely lined with epithelium, having been established at the base of the web, this is severed by rectangular flaps as in Didot's operation (see Fig. 80). The dotted line indicates the outline of the dorsal flap; the palmar flap is cut with its base in the opposite direction.

and not till then, the remainder of the web is dealt with as in Didot's operation (Fig. 79). The proximal end of each incision terminates on the lateral margin of each lower aspect of the foramen so that each flap carries with it, as it is raised, a portion of the epithelium, lining the opening. The deeper tissues of the web are severed, and if bulky, removed, and the flaps are sutured with silkworm gut into place, taking especial care that no raw surface is left at the base of the cleft. It is well to retain the glass rod in

situ, and it is always my endeavour to avoid the necessity of dressing the wound for at least fourteen days. In some cases it has been left as long as three weeks. The stitches are then removed, as the parts have healed.

In the after-treatment of these cases there is often noticed a tendency for the fingers to become laterally deviated if the web has been thick. Frequent manipulations, alternating with the use of very small malleable iron splints, or of a piece of soft iron covered with wash leather to fit the hand and fingers, are called for.

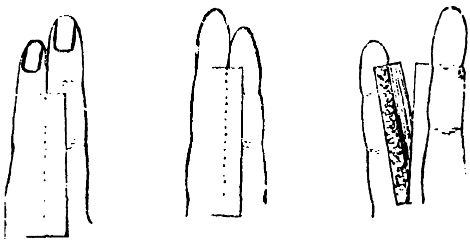


FIG. 80. Diagram of the Incision and Flaps in Didot's operation. The dotted lines show the limits of the flaps on the adjacent fingers.

5. The formation of a permanent opening at the bottom of the web by transfixing it with a silver pin or a piece of rubber and vulcanite is not satisfactory. The idea is to leave the foreign body *in situ* until the sinus has become lined with epithelium. But, unfortunately, the rod will not remain *in situ*. It moves gradually downward towards the tips of the fingers, and the tissues close above it.

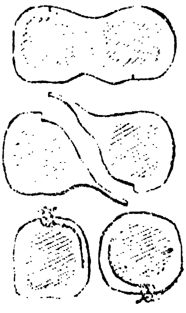


FIG. 81.—Transverse section of the affected fingers, showing the method of adjusting the flaps in Didot's operation.

After the bottom of the cleft has become lined with skin, the web may be either simply divided—and Zeller does this usually at once—or the actual division may require to be complicated by a plastic operation. The course to be adopted depends upon the characters of the web. A thin membranous web, similar to that seen in aquatic animals, may be dealt with by simple division. But when, as is generally the case, the fusion is fibrous or bony, simple division will leave such extensive raw surfaces on the opposed side of the affected fingers that fresh union may quickly take place. In order to obviate this, Didot (Figs. 80 and 81) devised an ingenious operation.

6. *Didot's Operation.*—An incision is made along the palmar surface of one finger, and is joined at each end by short transverse

cuts, so as to form a flap. On the dorsum of the other finger a similar proceeding is carried out, except that the flap is in the opposite direction. The remaining tissues of the web are then divided, and the dorsal flap of one finger covers the palmar surface of the other. There are certain points to be observed during and after this operation. These are:—(*a*) The two fingers are not of the same size, and the flaps should be cut accordingly. (*b*) The flaps must not be too broad, otherwise raw surfaces will be left on the fingers. (*c*) The sutures must be accurately adjusted at the bottom of the new cleft, so as to leave no granulating surfaces. This is unfortunately a most difficult thing to accomplish, and failure in this respect usually vitiates the operation. (*d*) The cleft must be carefully watched to prevent the formation of new adhesions. In the author's opinion however, frequent dressing of the cleft is a cause of irritation, granulations spring up, and reunion takes place.

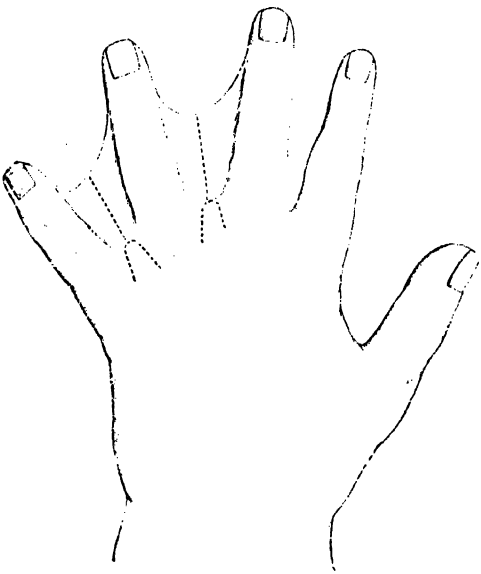


FIG. 82.—Diagram to illustrate Norton's operation for Webbed Fingers. Triangular flaps with the apices downwards are cut on both palmar and dorsal surfaces.

(*e*) The operation is not easy to perform satisfactorily on a small hand, and should therefore be deferred till the child is three or four years of age. (*f*) It is not likely to be successful if the fingers are closely joined, because the size of the skin flaps must be so considerable that a very large raw surface must be left denuded. Fibrous tissue forms, and gives rise to lateral contraction of the fingers.

7. *Norton's Operation.*[1]—Small rounded anterior and posterior flaps are made at the base of the cleft (Fig. 82), with their bases at the heads of the metacarpal bones. The web is divided, and the

[1] *B.M.J.*, August 1881.

flaps joined at their apices. The following points should be attended to:—(*a*) The flaps should be thick, so that their vascular supply is good; (*b*) They should be rather narrow, to prevent bulging; (*c*) The tissues between the heads of the metacarpal bones should be cut back or removed, so as to allow the flaps to meet well; (*d*) The flaps must be long enough to prevent tension; (*e*) In joining the flaps small needles and fine sutures must be used, so as to injure the tissues as little as possible; (*f*) The new web must be in a line with the natural one; (*g*) The fingers must be kept apart as much as possible during the healing process.

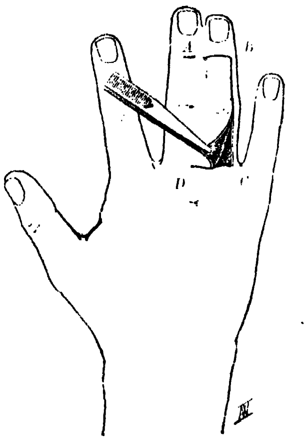


FIG. 83.—First stage of the operation by Forgue for Webbed Fingers. The lettering is explained in the text (Berger and Banzet).

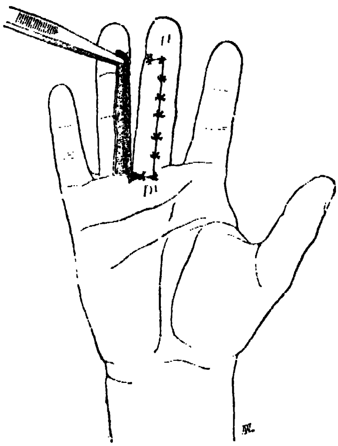


FIG. 84.—Second stage of Forgue's operation. The Web having been divided, the flap *ABCD* shown in the previous figure is wrapped round the middle finger A^1D^1 (Berger and Banzet).

8. Another procedure which requires mention is that of Forgue (Figs. 83-86). ABCD is a quadrilateral flap, taken from the dorsum of one finger and of the web (Fig. 83). After it is raised sufficiently (at C this is being done), the web is completely divided. The finger (AD) is then covered on its lateral aspect by the prepared flap (Figs. 83 and 84). This leaves a quadrilateral raw surface on the dorsum of the finger (C), which is covered by a flap (DEFGH (Fig. 85)) turned up from the back of the hand; the exposed surface left by doing this being in its turn covered by drawing the skin together, which is easy on the back of the hand, as the integuments are loose there.

Choice of Operation.—In all cases it is essential to secure an opening of sufficient size and in the right direction at the base of the web.

1. This in the writer's opinion can best be effected by the method and apparatus he employs, described on pp. 94-99. And it should constitute the first stage in the treatment, nothing further being attempted until complete healing has taken place.

2. If the web is thin, membranous and incomplete, it may

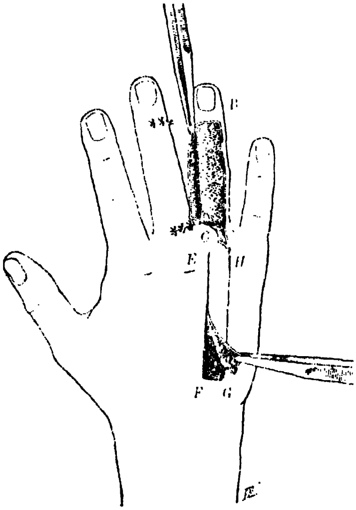


FIG. 85.—The third stage of Forgue's operation, the formation of a flap *EFGH* from the dorsum of the hand to cover the raw surface *BC* (Berger and Banzet).

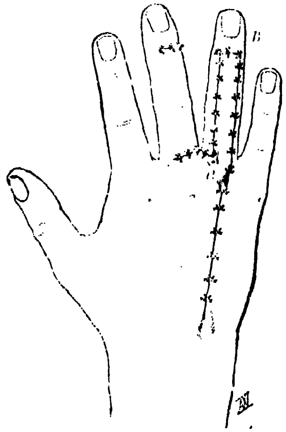


FIG. 86.—The final stage of Forgue's operation. The flap from the dorsum of the hand is transposed so as to cover the raw surface *BC*, and the skin edges on the dorsum of the hand are sutured together (Berger and Banzet).

then be completely divided, care being taken to keep the raw surfaces apart.

3. In those cases where the web is extensive, thick, and the fingers are close together, the surgeon must make his choice between the operation described as Félizet's (p. 94), and performing the following operation, as devised by the author:—

The epithelial fistula is first made and lined by flaps as described on p. 94, and, satisfactory union having taken place, at a second operation the web is completely divided. Two large raw surfaces are now left. The skin at the edges of these surfaces is carefully undermined with a sharp tenotomy knife, and sutures are inserted, drawing the skin edges of each finger as closely

together as may be possible without any tension whatsoever. In this way it is found that the raw surfaces to be covered are diminished by one-third to one-half. By this time all bleeding will have ceased, yet if any considerable artery gives rise to trouble it should be seized and twisted, but never ligatured, as the ligature is sure to give rise to delay in healing. And here it may be mentioned that the best material for the sutures is fine silkworm gut, stained with aniline blue black, as the colouring facilitates their removal.

Now the point of this operation is to secure healing as quickly as possible. In order to avoid irritation of the raw surfaces, gauze should not be immediately applied to them, but strips of sterilised tin-foil placed on them, or wrapped round them very carefully. Then plain gauze is carefully applied in strips to each finger, and a wedge of gauze pushed in between them. The hand is then bound up, and the limb from the elbow downwards firmly fixed on a splint. In many children it is necessary to tie the arm to the side. The dressings are not removed for three weeks, and it will then be found that the raw surfaces have become entirely covered by epithelium, and the result is satisfactory. It only remains to remove the stitches, which, if the operation has been completely aseptic, will not have given rise to any granulations. Even where the union has been partly bony, especially where the synostosis affects the second and third phalanges, this form of operation has been most successful.

SUPERNUMERARY FINGERS—POLYDACTYLISM

More than five fingers are sometimes present. As many as eight digits have been seen on a hand,[1] and once the presence of nine digits on a foot has been recorded. Usually abnormalities, such as syndactyly and a rudimentary condition of some of the fingers, are also present.

The condition is often hereditary, and may be traced through several generations, and frequently exists both in the toes and in the fingers. Generally the supernumerary digits are marginal, less often central (see Fig. 87). There is seldom any great difficulty in deciding which fingers are supernumerary, especially

[1] Cf. Rasch's case, *Beiträge z. klin. Chir.* Bd. xviii. Heft 2, 1897; and two cases of bifurcated hand, that is a hand having eight fingers and no thumb (Murray, *Med. Chir. Trans.*, 1865); Giraldès, *Maladies chir. des enfants*, Paris, 1865.

with the aid of skiagraphy, since they are usually ill-developed, abnormal, and devoid of a corresponding metacarpal bone.[1]

It is difficult to speak of types, as the individual cases vary so much, but the most frequent form is a supernumerary little finger. Next to that is a double thumb, or *pollex duplex*. Sometimes the additional thumb possesses three phalanges (Klaussner). In other cases each thumb possesses two phalanges, and each has its own metacarpal bone. Further, the movement in both is good.

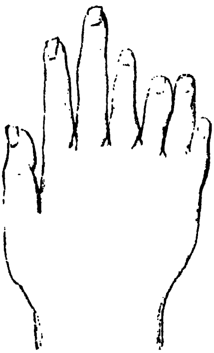


FIG. 87. — Supernumerary Fingers — Polydactylism, of the Central Variety.

It sometimes happens that the supernumerary digit, more or less perfect, is closely united throughout its whole length with another digit. This condition is also seen more often in the thumb than elsewhere.

Treatment. — Polydactyly always calls for surgical intervention. It is a deformity and a prominent one, and is ever a disability. Before deciding to operate, a skiagram should invariably be taken, so as to avoid the possibility of amputating the wrong digit. Then the supernumerary digit should be disarticulated and removed.

In the very rare event of being unable to decide which is the offending finger, removal of the additional finger on the ulnar side will generally be correct.

Many cases do not require disarticulation, as the digit is only attached by skin and membrane. Simple ablation is all that is needed.

SUPPRESSION OF THE FINGERS

Such a condition is of interest to the teratologist rather than to the practical surgeon. The fingers may be deficient either in number or in length, owing to the absence of their segments, or both abnormalities may be present. Such defects may be classified as marginal, central, or terminal.

[1] Before the advent of skiagraphy mistakes were made, and the wrong digit removed. In a young lady, the daughter of a medical man, who was born with six toes on one foot, the true digit was removed, leaving a supernumerary digit, which, being the outer one, soon became displaced, and was a source of pain and weakness. Having ascertained the state of affairs by X-rays, I deemed it possible to bring the bony base of the supernumerary digit into articulation with the head of the metatarsal bone, and was successful in doing so and in improving the appearance of the foot.

In *marginal* defects of the digits, the thumb or little finger is lacking, and in severe cases the adjacent fingers as well. Usually the marginal defects are associated with absence of the radius or ulna, but this is not always so.

By some observers[1] *central* defects, when well marked, and especially when the corresponding metacarpal bones are lacking, are sometimes spoken of as claw-hand, lobster-claw hand, or cleft hand.[2]

Terminal defects, or abnormal shortness of one or more fingers, may be due to various conditions. A short and relatively broad finger, or brachydactylia, according to Joachimstal,[3] may be due to a reduction in length of one of the constituent elements,

FIG. 88.—Suppression of Fingers (? Intra-uterine Amputation), also Congenital Constrictions of the Forearm.

metacarpal[4] or phalangeal, without any diminution in their number; or a phalanx may be suppressed entirely, but this is rare.

Another form of terminal defect is that in which, instead of the normal finger, there is found a deformed stump, very similar in appearance to that seen after surgical amputation. In fact the impression is conveyed to the observer's mind that the absence of the ends of the fingers is due to their amputation *in utero*. The co-existence of congenital furrows and annular constrictions, which is so frequent (Fig. 88), forcibly suggests that amputation, by means of constricting bands of amnion or coils of umbilical cord, has taken place. That such causes explain this condition

[1] Vogt, *Préface des mammifères*.

[2] For an interesting example of this deformity, which extended through five generations, and was associated with cleft-foot, see *Deformities*, 1st ed. p. 506.

[3] *Virchow's Arch.* Bd. cli. S. 429.

[4] Roughton, *Lancet*, vol. ii. p. 19, 1897.

is borne out by the facts that on very rare occasions a granulating surface has been seen, and the remains of the amputated finger have been found loose at birth.[1] The author is convinced that remains of amputated fingers and toes would be much more frequently found at birth, if they were carefully looked for.

In other cases, rudimentary fingers are present on a truncated and deformed limb, and the limb is much shortened. It has been plausibly suggested that these are rare cases in which the constriction of the bands has not been sufficient to cause complete amputation, but has been enough to interfere with the development of that portion of the limb beyond the bands.

HYPERTROPHY OF THE FINGERS

This condition is sometimes seen at birth in a minor degree, and becomes exaggerated later. The following forms are described:

1. Hypertrophy of all the tissues of the finger.
2. Lymphatic enlargement of the subcutaneous tissues.
3. A naevoid condition of all the soft structures (Billroth).
4. The presence of supernumerary phalanges.

Relative lengthening also of one digit may be due to shortening or brachydactyly of the others. In those rare cases in which skiagraphy shows a supernumerary phalanx (Joachimstal, Lébouеq, Klaussner), known as hyperphalangia, the finger is not necessarily longer than normal. Thus in Klaussner's case a little finger had four phalanges, but was shorter than normal, owing to these phalanges being very short, that is, brachydactyly and hyperphalangia were combined. Three phalanges to a thumb is a rare condition, and has only been seen in a case of double thumb.[2]

To return to the first variety mentioned, namely, hypertrophy of all the tissues of the affected fingers. This is sometimes described as "gigantism." The writer has met with several cases, mostly affecting the thumb and first finger. Hawkins-Ambler[3] describes and figures a case in which the ring and little fingers were affected on both hands (Fig. 89).

Pathologically, it is observed that the arteries passing to these fingers are larger than normal, and the temperature of the part is generally raised.

[1] Klaussner, *op. cit.* p. 105.

[2] Rasch's case, *Beiträge f. klin. Chir.* Heft 2, 1897. Klaussner's case, *op. cit.* p. 140. H. Hermann, *Inaug. Dissert.*, Munich, 1895.

[3] *Lancet*, 4th February 1893.

As to treatment, elastic compression of the fingers and ligature of the arteries have been tried, but unsuccessfully. So long as the hypertrophied parts are useful, and not a hindrance owing to their size, they should be retained, and especially is this the case with the thumb, which is not to be removed without great hesitation.

FIG. 89.—Congenital Hypertrophy of the Ring Fingers (Hawkins-Ambler).

But a hypertrophied finger, when it constitutes a source of annoyance, is better amputated.

Lymphatic enlargement of the subcutaneous tissue is due to obstruction of the lymphatic circulation in the limb above. It is to be distinguished from a curious congenital lipomatous condition seen occasionally in the hand, but more often in the foot, which is progressive, and when removed recurs *in situ*; or if the part is amputated, it sometimes recurs higher up the limb.

CONGENITAL DIFFUSE LIPOMA

This lipomatous condition presents many points of interest. Beginning in one or more fingers or toes, it spreads to the adjacent

is of appropriate age to appreciate its significance, an arthrodesis at the knee may be performed.

Congenital Curvature of the Leg

It is very rare for both bones to be thus affected, but the writer has had one case sent to him with the diagnosis of congenital talipes calcaneus. Examination, however, showed that the foot was in normal relationship with the bones of the leg, but there was an abrupt curve of the tibia and fibula, situated just above the ankle, and with the convexity pointing backward and outward.

Absence of the Tibia or Fibula and Congenital Curvature of the Leg

Either of the bones may be partially or entirely absent, the tibia with congenital equino-varus, the fibula with congenital equino-valgus.

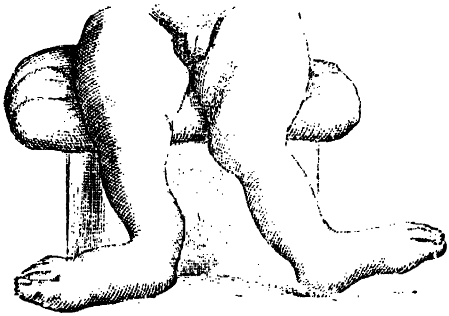


Fig. 91.—Congenital Absence of the fibulæ and Talipes Valgus (Mensel).

The fibula is more often defective than the tibia. Absence of the patella, genu recurvatum, congenital dislocation of the knee,[1] and shortening of the femur often co-exist.

With partial or entire defect of the fibula, the tibia is curved at the junction of the middle and lower third; it is also shortened. The convexity of the curve looks directly forward. At the summit of the convexity a depression of skin is often seen, and it is usually adherent to the bone. In the writer's opinion both the curvature and the dimple are due to an amniotic adhesion, the curvature being produced by the pull of the band, and the dimple indicating the site of its attachment and subsequent separation.

[1] Cf. the description of congenital dislocation of the knee, vol. i. p. 121.

By some writers the dimple (Figs. 92, 93) has been thought to arise from an intra-uterine fracture of the tibia, the end of the bone projecting through the skin. In the first edition of this work,[1] there is recorded a striking case of congenital talipes valgus, absence of fibula, forward curvature of the tibia, depressed scar, and ununited fracture of the tibia existing from birth. This case lends some support to the idea that a compound fracture is the cause of the dimple. And in this connection the author desires to record that

FIG. 92.—Congenital Absence of the right fibula, congenital curvature of the tibia with a depression of the skin over the crest of the tibia, and Talipes Valgus.

FIG. 93.—A similar condition, in the left leg, to that seen in the preceding figure.

the only case of ununited fracture he has had after an osteotomy in his own practice, was one following an operation for congenital curved tibia. Every measure was tried to obtain union, but without success.

The prognosis of these cases of defective or deficient tibia and fibula is bad. Not only is the growth of the limb retarded, but also it is found impossible to retain the foot and the limb in a satisfactory position by any form of apparatus. If the prognosis in defective fibula is bad, still worse is it when the tibia is absent. Arthrodesis has been performed at the ankle, and in some cases at the knee as well. But as the child grows and its weight increases, the question arises whether an artificial limb is not better than the shortened, distorted and often painful one.

[1] Tubby, *Deformities*, 1st ed. p. 360.

Congenital Hammer-Toes

This deformity is associated with congenital contraction of the fingers, for when the fifth fingers are so affected, the second toes

Fig. 94.

Fig. 95.

Two views of a case of Congenital Hammer-Toe.

are found to be contracted. In some cases, however, the hammer appearance is not confined to the second, but is seen in the third, fourth, and fifth toes. The structures usually shortened are the

PLATE IX.

FIG. 1.

Radiogram of the lower extremities of an infant with Congenital Contraction of the Knees. Absence of the Fibulæ, and of some of the Metatarsal Bones and Toes.

PLATE IX. *Continued.*

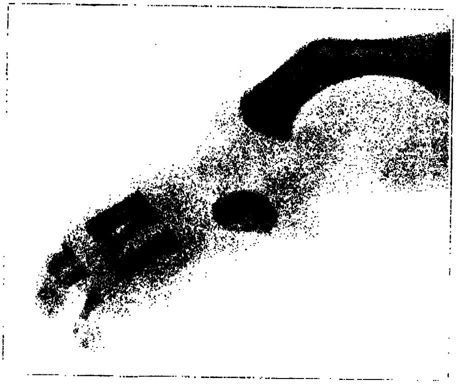


FIG. 2.

FIG. 3.

Radiograms from a case of Bilateral Congenital Absence of the Fibulæ, and of some of the Metatarsal Bones and Toes.

flexor tendons, and later the lateral ligaments and extensor tendons.

The treatment is conducted on the same lines as in acquired hammer-toes (*q.v.*). In no case should the digit be amputated. The space left after removal of the second toe permits the great toe to be forced outward by the boot, and a bunion follows.

Congenital hammer-toes should not be confused with the contracted toes of equino-varus. In the former the foot is otherwise normal.

FIG. 96.—A view of the front of a foot in which the second toe has become "Hammer-like."

Lateral deviation of the toes is frequently met with as a

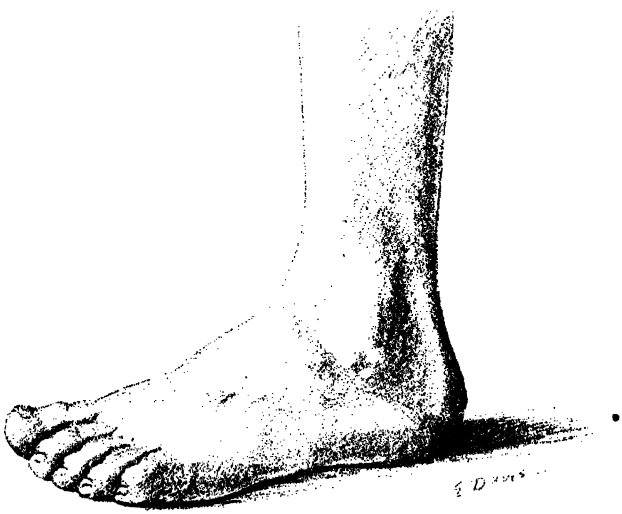


FIG. 97.—A view of the foot in Figs. 94, 95, showing the cure of Hammer-Toe after the Subcutaneous Operation.

congenital deformity, and affects the third and fourth toes more

often than the others. In infancy it is treated by frequent manipulation, placing a pledget of cotton wool between the deviated digit and its neighbour, and by wearing a small malleable iron hammer-toe T-splint with a flange on the toe part to abut against the concave side of the toe. As the toe is pressed against the flange it is gradually straightened. If this fail, then the resisting structures are divided.

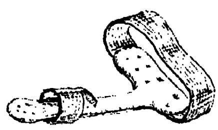


FIG. 98.—The T-splint used in the Post-Operative Treatment of Hammer-toe

Pigeon-toe, or varoid inclination of the great toe of congenital origin, is mentioned (p. 294) as a slight degree of congenital varus.

OTHER DEFORMITIES OF THE TOES

Syndactylism, polydactyly, suppression of one or more of the toes, occur as in the hand, but are not of great importance. When the number of toes is excessive, the redundant members should be amputated, but care must be taken that the abnormal ones are removed, and not those which have complete articulations with the metatarsal bones. In some instances the only method of being certain is to examine radiographically before the operation.

Gigantism and **congenital lipoma** more often affect the foot than the hand.

Suppression of segments of the lower limb is occasionally met with. Thus, I have seen the upper three-fourths of the femur wanting, and merely the lower epiphysis present, which was in contact with the pelvis. However, in this case the child was able to walk well with the help of a surgical boot, and a long wooden pin fixed to the sole to compensate the shortening. As he had complete control over his defective limb, it was obviously the wiser course to fit him with a boot rather than to amputate just below the pelvis.

Intra-uterine amputation at any point in the lower extremity is seen, and does not need any special description.

Congenital Contractions of the hips or knees are rare. They appear to be due to retention of the limbs in one position *in utero*, or they are due to the irritation arising from the central lesions of congenital paraplegia and diplegia. They usually yield to splints and manipulation.

Cleft Foot is rare. The hands and feet of a case with a

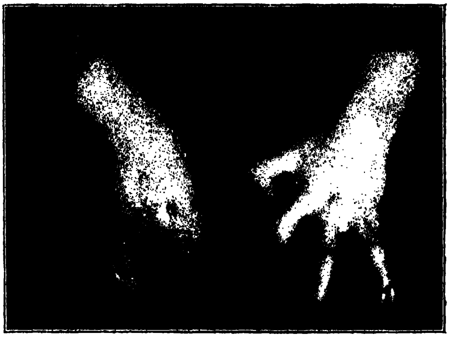


FIG. 99.

FIG. 100.
Cleft Hands and Feet (Lobster-Claw Deformity of the Feet).

hereditary history for five generations are figured here[1] (Figs. 99 and 100).

[1] Cf. "Split-Hand and Split-Foot Deformities: their Types, Origin, and Transmission," by T. Lewis and D. Embleton, *Biometrika*, vol. vi. pt. i., March 1908—a very complete and fully illustrated account of this rare deformity.

CHAPTER IV

CONGENITAL DISLOCATIONS

Of the Lower Jaw, the Spine, the Clavicle, the Shoulder, Elbow, Wrist, Thumb, and Fingers—Congenital Subluxation of the Hip—Congenital Dislocation of the Knee, Patella, Ankle, and Bones of the Foot.

The Lower Jaw

Imperfect development of the jaw with partial congenital dislocation has been seen. Frequently, some other deformity is present, such as persistence of branchial clefts, malformations of the ear, and macrostoma. The direction of displacement in the recorded cases is either backward, or both forward and backward. The treatment of this deformity is evidently to retain the articulating part of the lower jaw in as close contact with the glenoid cavity, or what represents it, for as long as possible, in the hope that the depression will be deepened and stability follow. If this fail, the parts may be retained for many months in apposition by means of a wire or silk-worm gut suture passed through the zygoma above, and the articular part of the jaw below, as the writer has done successfully in recurrent acquired dislocation.

The Spine

In monstrosities, the cranium is sometimes displaced forward or backward on the vertebral column. Partial dislocation of a vertebral body from its neighbour is not uncommon in congenital scoliosis.

The Clavicle

Congenital dislocation of the clavicle either at its inner or outer, or at both extremities is exceedingly rare. Guérin, however, records

a case of the last-named variety. Treatment by splints and bandages is not likely to be effectual, and it will be necessary to operate in order to reduce the displacement and fix the parts in place.

THE SHOULDER

This is a condition somewhat analogous to congenital luxation of the hip,[1] and perhaps is due to a similar cause, namely, imperfect development of the socket. It is a rare condition, and must not be confounded with traumatic dislocation taking place during birth, or with obstetrical paralysis[2] or separation of the upper humeral epiphysis.

In most of the cases reported the dislocation is posterior, the head of the humerus resting just below the junction of the acromial process and the spine of the scapula. The writer has seen one such case at the Evelina Hospital for Children.

Symptoms.—The first to attract attention is defective mobility of the upper arm, the humerus being abducted and rotated. Skiagraphy is of value, and the usual electrical tests show the absence of paralysis. Scudder[3] states that if any lack of development is shown by measurement of the humerus on the affected side at birth, there is considerable probability of true congenital dislocation being present.

Diagnosis.—The affection is to be carefully distinguished from obstetrical and infantile paralysis and separation of the upper epiphysis of the humerus.

Treatment.—Reduction should be attempted, and if successful, the head of the humerus is to be kept in position until the arm can be moved without recurrence of the deformity. Reduction may be easy, or require prolonged forcible manual stretching of contracted muscles and ligaments.[4] Even continuous traction may be needed.[5]

The operative procedures described by Phelps are at present to be regarded as tentative.[6]

[1] R. W. Smith, *Fractures and Dislocations*, 1847, p. 569; Robinson, *Lancet*, 1893, vol. i. p. 475; Eve, *Clin. Soc. Trans.*, 1895, p. 299; Lewis, *Philad. Med. News*, 1895, p. 183; Stimson, *Fractures and Dislocations*, 1899, p. 592.

[2] The author has met with cases, diagnosed as congenital dislocation of the shoulder, which were obviously obstetrical paralysis.

[3] *Arch. of Pediat.*, April 1890; and *Amer. Jour. of Med. Sci.*, February 1898.

[4] Royal Whitman, *Orthopedic Surgery*, 2nd ed. p. 473.

[5] Berger and Banzet, *op. cit.* p. 162.

[6] Peckham, *Amer. Jour. of Orth. Surg.*, April 1905, in an important paper states

As to the position in which the head of the bone should be retained for a prolonged period after reduction, Whitman states that "the humerus should be well abducted on the scapula, with its upper end pointing forward and the arm rotated outward." Careful manipulations and exercises are subsequently followed. If relapse occurs, and the arm is much disabled, arthrodesis of the shoulder joint should be performed.

The Elbow

Complete dislocation of both ulna and radius is met with very seldom. According to Kölliker only three cases had in his time been described. Dislocation of the ulna alone has not, so far as the writer is aware, been recorded.

W. E. Blodgett,[1] however, has analysed and summarised fifty-one cases of dislocation of both bones, including two of his own cases.

The symptoms are similar to those of the traumatic form, but the condition is congenital, and is usually associated with malformations elsewhere, such as club-foot or deficiency of the bones of the fore-arm. The dislocation is usually either forward or backward, less frequently it is outward. In about one-third of the cases there is bony fusion of the upper ends of the radius and ulna.

Limitation of movement may necessitate excision of the head of the radius (Hoffa, Bessel-Hagen, La Ferté), or even of the elbow. Special procedures may also be called for in view of the associated abnormalities of the bones of the fore-arm.

The Wrist

This lesion, apart from osseous deficiency and club-hand, is a very unusual abnormality. Hoffman describes a case in a child a few days old. "The right carpus was displaced forward, the

that he operated on two cases by Phelps' method, but was not satisfied with the result, and proposes to try traction and manipulation in any other case which comes under his notice.

[1] *Amer. Jour. of Orth. Surg.*, Jan. 1906. He also gives the following references:— C. A. Powers, *Jour. of Amer. Med. Assoc.*, 1903, vol. xli. p. 165; Blumenthal, *Zeitschr. f. orth. Chir.*, 1904, xii. Hefte 1 and 2; Bonneberg, *ibid.*, 1893, vol. ii. p. 376; F. C. Abbott, *Path. Soc. Trans.*, London, 1891-1892, vol. xliii. p. 129. Also *Lancet*, 1892, i. p. 800; Stimson, *Treatise on Dislocations*, 1888, p. 319. He gives 37 additional references. Kölliker, Joachimstal's *Handb.*, adds the following: Amburd, *Rev. d'orthop.*, 1901, No. iii.; Heele, *Lancet*, 1886, vol. ii. p. 993; G. M. Humphry, *Med. Chir. Trans.*, 1862, vol. xlv.; Weszkalnys, *B.M.J.* vol. ii., 1883.

ligaments were relaxed, and the dislocation could be temporarily reduced. The bones were normally developed." By way of treatment, shortening of the extensor tendons and arthrodesis have been suggested.

It should be carefully distinguished from Madelung's Wrist (p. 301).[1]

The Thumb

The writer has met with one instance of congenital dislocation forward at the metacarpo-phalangeal articulation. It was seen in a girl aged ten years. On the right side there was dislocation, with contraction of the long flexor tendon. On the left side the latter condition alone was present. The case was treated by open operation, the short tendons being lengthened; on the right side the ligaments of the joint were freely divided, and the bones replaced. After remaining in splints for two months, the reduction was permanent, and good movement seemed secured.

The Fingers

Chaussier[2] instances a fœtus in which the outer three fingers were dislocated at the metacarpo-phalangeal articulations.

Subluxation of the Hip

Congenital dislocation of the hip is a large subject, and is treated in subsequent chapters. A minor degree of dislocation exists, called congenital subluxation. It is characterised by a slight limp and shortening. A Röntgen-ray picture shows that an acetabulum exists somewhat above the plane of the opposite side. The head of the bone slips upward and forward in walking, but does not entirely leave the socket. These cases are best treated by abduction and fixation.

The relationship of coxa valga, subluxation and congenital dislocation of the hip are considered on pp. 619 *et seq.*

[1] *Trans. Amer. Orth. Assoc.* vol. xviii. p. 96; and V. P. Gibney, *ibid.* p. 97; also Joachimstal's *Handb.* Lief. v., and Mayer, *Verhandl. f. Handels. d. Phys.-Med. Gesells.*, 1855, Bd. v., Würzburg.

[2] Cf. also Bérard, *Dict. de méd.*, Art. "Main," vol. xviii.

Congenital Dislocation of the Patella and Knee

Development of the Knee-Joint.—The knee-joint appears about the sixth week of embryonic life, and at that time the fibula is in contact with the femur, but later the former recedes, so that ultimately the knee-joint consists of the femoro-patellar and the femoro-tibial articulations.

Congenital Affections of the Patella

Congenital deformity or deficiency of the patella existing without any other anomaly is rare, but in conjunction with congenital dislocation of the knee and talipes varus and valgus, it is not so uncommon. Cases of complete absence of the patella with no other deformity and functional disability have been described by Brunner and Worth. Duplication or longitudinal splitting of the patella, the normal condition in the carnivora and rodents, has been described once in man by Joachimstal.

Congenital Dislocation of the Patella

The usual form is outward, either partial or complete. Thus Bajardi[1] describes a case in which the displacement was partial on the right and complete on the left side. Upward displacement is rare, it is seen in congenitally spastic cases, and is associated with congenital dislocation of the knee. Steindler[2] collected 67 cases of the latter deformity, of which 64 were outwards, 3 were upwards, and none inward. Occasionally the affection is hereditary. Schön[3] reports a case of dislocation of the left patella, and the patient's mother and one sister had a similar deformity.

The patella is often in place when the knee is extended, and is displaced on flexion. It is sometimes displaced so far laterally, that, carrying with it the quadriceps, the lower part of the femur is laid bare. Congenital genu valgum is seen, although Steindler says it is secondary; we have, however, met with cases which disprove this assertion. The function of the joint is often remarkably good, although the subjects of the deformity are late

[1] *Arch. d. ortoped. ann.* xi. vol. iv. He collected 34 other examples.

[2] "Über die angeb. Luxation der Patella," *Zeitschr. f. Heilk.* Bd. xix. Heft 4. This article contains the complete literature of the subject to 1898.

[3] *Ugeskrift f. Laegar*, 1893, Nov. 17.

in walking. When the displacement is intermittent, serious disability arises.

Treatment.—This is called for only in the intermittent form, and if genu valgum is present. Walking apparatus with steels on either side of the limb, and pads to hold the patella in place, are required when genu valgum exists, while a firm leather or leather and steel knee-cap suffices for the slighter cases. Various operations have been carried out. In external displacement the author has attached the sartorius to the upper and inner edge of the bone. Le Dentu has taken up a longitudinal fold of the inner part of the capsule of the joint. Roux suggested attaching the ligamentum patellæ to the inner side of the tibia; and Heussner has combined pleating the capsule of the joint with attachment of the semi-tendinosus to the inner border of the patella.

Congenital Dislocation of the Femoro-Tibial Joint

The usual variety is forward, and may be partial or complete. Pure lateral displacement, either valgoid or varoid, is rare. Drehmann collected 127 cases in 1899,[1] and 106 were forward. Of the latter 49 were bilateral, 6 "voluntary," 6 were single and backward, 3 were single and outward, 2 were single and inward, 5 were double and backward, 3 were mixed bilateral, being backward on one side and forward on the other.

Luxation Forward of the Tibia is the most usual variety. The latest writers follow Albert, who stated that most of these cases are more correctly named "genu recurvatum." Drehmann, however, is of opinion that this term is applicable only to those cases in which, although hyper-extension is present, no limitation of flexion exists. In them the condyles of the femur and the head of the tibia are in normal relationship, and the ligaments are relaxed. Such conditions are seen associated with congenital dislocation of the hip and club-foot. Cases of genu recurvatum, if untreated, develop into true dislocation (Figs. 101, 102, 103).

Symptoms.—The leg is hyper-extended and the skin is creased transversely over the patella. In the popliteal region there is a fulness, and on palpation the posterior aspect of the condyles and the intercondyloid notch are easily felt. The patella is often imperceptible in infancy, but later it appears; it is very small and situated higher up the limb than is normal. On attempting to flex

[1] *Zeitschr. f. orth. Chir.* Bd. vii., with full bibliography to 1899.

the limb, elastic resistance is felt. As a rule no lateral movement is present.

As the child grows, the hyper-extension becomes less, partly because of the effects of gravity and of the weight of the limb, and partly from passive and active movements of flexion. Later, as the child runs about, complete dislocation forward of the tibia may occur, very similar to the condition seen in traumatic cases. If the dislocation is bilateral, the ligaments are more relaxed than in unilateral cases, and complete dislocation occurs sooner.

Complications.—Talipes calcaneo-valgus, and occasionally varus, and relatively frequently, congenital dislocation of the hip are present.

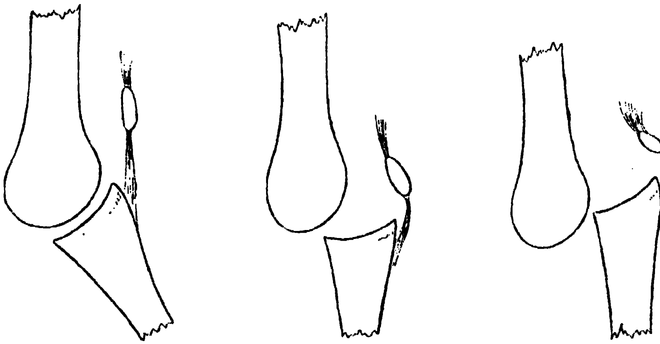


FIG. 101. FIG. 102. FIG. 103.

Three figures showing the development of untreated Congenital Genu Recurvatum into complete dislocation. (Drehmann.)

Pathology.—The capsule of the joint is intact, but it is abnormally relaxed; the patella is small or absent, and does not articulate with the femur; the extensor quadriceps is shortened; and the biceps is often dislocated forward, and may act as an extensor of the leg (Fig. 104).

Many reasons have been given to explain the appearance of this rare deformity. We have noted its association with congenital dislocation of the hip and with talipes calcaneo-valgus. Uterine malposition is the most likely cause, particularly hyper-extension, a prominent factor in the ætiology of congenital dislocation of the hip.

Prognosis is on the whole satisfactory, and spontaneous recovery may occur, but it is not advisable to wait for this event. It is better to commence treatment at an early date.

Treatment.—Forcible flexion has been employed even in

infants; but instead of reducing the dislocation, it may produce a subluxation of the tibia forward (Fig. 103); or even result in separation of the epiphyses. Simple flexion may be totally impossible because of the forward displacement of the hamstrings (Fig. 104). Drehmann practises the following manœuvres:—The leg is further hyper-extended, and the tibia is freed by lateral movements. Then, while the leg is in this position, pressure is exerted downward on the sole of the foot, *i.e.* toward the knee, thus pushing the head of the tibia downward and backward, while the hamstrings are relaxed. Counter-pressure is applied against the condyles of the femur, and a rapid movement of flexion is made. If successful, the springy resistance to flexion is lost and the knee is bent. Afterwards, the limb is put in plaster of Paris or on a bent malleable iron splint, and the patient is allowed to walk about.

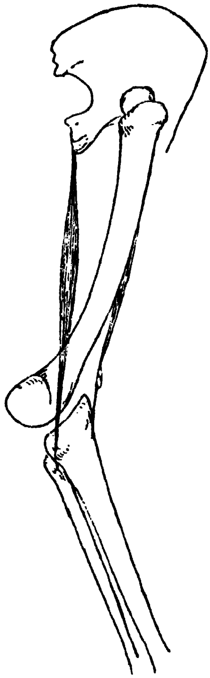


FIG. 104.—Dislocation of the Biceps forward in Congenital Dislocation of the Knee, so that it has become an extensor of the leg. (Drehmann, after Muskat.)

We have treated the few cases which have come under our notice by gradually reducing the hyper-extension. We fit a malleable iron splint to the back of the limb, and about once a week reduce the angle until the knee is straight, and later is flexed. So soon as the limb can be straightened, we massage the muscles of the thigh and leg, and prescribe a support which permits flexion movements, but prevents any hyper-extension by a "stop" opposite the knee-joint. We have noted in all our cases, while under treatment, the gradual appearance of a tiny nodule in the ligamentum patellæ, which has increased until finally it has attained the size and shape of a normal patella. We do not know if it appears in untreated cases. As recent references to congenital defects and dislocation of the patellæ and knee are widely scattered in surgical literature, we give a brief *résumé* up to date:—

Helbing (*Berliner klin. Wochenschr.*, 1905, 10) describes four cases of congenital dislocation of the knee and patella, all due to intra-uterine malposition, and associated with club-foot and congenital hip.

Magnus (*Deutsche Zeitschr. f. Chir.* xxiv.) describes three children in

one family with total knee-luxation. In the third case, although the child had not attempted to walk, the dislocation was still total. He thinks the deformity is due to primary laxity of capsule and ligaments. In one case the quadriceps was lengthened by operation, and the anterior crucial ligament shortened. He advises operation, after prolonged instrumental treatment has failed.

Ewald (*Archiv f. klin. Chir.* Bd. lxxviii. Heft 4) describes congenital luxation of the patella, combined with club-foot, in two children of a family. He shows that when the quadriceps begins to functionate, the patella grows.

Max Haudek (*Zeitschr. f. orth. Chir.* xvii. p. 457) describes his appliance for the treatment of habitual luxation of the patella. He also mentions that the anterior aspect of the femoral condyles is abnormally flattened.

H. Bogen (*Münchener med. Wochenschr.*, 1907, 14) describes a case of "left-sided, congenital, and complete luxation of the patella." The mother had complete permanent luxation outwards of both patellæ. She had three children. The eldest was normal. The second had congenital smallness of the patellæ, but no luxation. The third had complete permanent luxation of the left patella, and incomplete habitual luxation of the right.

Heinrich Bogen (*Zeitschr. f. orth. Chir.* xvi. p. 359 *et seq.*) has written an elaborate article of sixty pages, with a most complete bibliography and very full references to "Hereditary Dislocation of the Patella."

He divides the cases clinically—

(*a*) Complete luxation.
   1. Intermittent or habitual.
   2. Permanent.

(*b*) Incomplete luxation.
   1. Intermittent or habitual.
   2. Permanent.

In the complete form the patella is entirely on the outer side. In the intermittent form it is in place on extension, and is displaced on flexion. Congenital luxation upwards in Little's disease is described. The luxations, however, are almost always outwards; some cases, inward, have been described, but their existence is doubtful.

Symptoms.—1. The intermittent form. "Habituelle luxation der Patella," "Déplacement spontané de la rotule," "Slipping patella." The disability is often very little, but sometimes it is severe. Walking on level ground is easy because the knees are not bent much. But walking downstairs is dangerous and falls are numerous, because the patella slips on marked flexion of the knee. Carrying burdens is also difficult. As the knee-cap slips, the quadriceps extensor becomes a flexor and the patient falls.

2. Permanent dislocation is not so likely to cause falling, but active extension is interfered with, because the quadriceps now acts as an abductor of the valgoid leg.

Perthes writes on "The Pathology and Therapy of Congenital Luxation of the Knee-Joint," *Zeitschr. f. orth. Chir.* Bd. xiv. 3 and 4.

R. Wehrsarg (*Arch. f. Orthopedie*, Bd. iii. Heft 3) observes that dislocation of the knee is apparently rare, because it is easily recognised at birth, is readily reduced, and the deformity does not tend to recur. It is probably more common in females and is bilateral. The causation is probably purely mechanical. No *complete* pre-femoral dislocation has been observed at birth.

L. Bacilieri (*Arch. f. Orthop.*, 1905, Bd. iii. Heft 3) says that hyperextension is not caused by shortening of the quadriceps, but by transposition of the insertion of the biceps forwards, so that this muscle really becomes an extensor.

P. Tridon (*Rev. d'orthop.*, Nov. 1905) discusses the co-existence of congenital dislocation of knee and hip. His chief points are:—

Observers are not agreed as to what is congenital dislocation of knee. The tibia in congenital knee is nearly always drawn forwards, and the articular surfaces are never entirely separated, so that the dislocation is always incomplete. In 121 cases of congenital dislocation of the knee, the hip too was found dislocated 20 times.

Mouchet (*Arch. de méd. des enfants*, 1905, No. 7) describes a case of congenital genu recurvatum in a baby of four months. The angle of the leg was 145°. It could be hyper-extended to a right angle, but not flexed beyond 180°. It was reduced by manipulation and fixation.

Reiner (*Zeitschr. f. orth. Chir.*, 1904, Bd. xiii.) describes the case of a boy aged eight years. The knees were bent forwards at right angles. He stood on his calves; and in progression he lifted the foot forward by the hand of the same side. There were corns over the femoral condyles. An open operation was done, and the "tibial plateau" was gouged to fit the condyles. At the end of seven months' time active flexion of the knees of 60° or 70° was possible.

Bullinger Müller, "Congenital Luxation of the Patella" (*Rev. d'orthop.*, Jan. 1906), remarks, "In some cases it has been possible to make out a new articular facet for the patella on the outside of the external condyle. When palliative treatment has failed he notes that:—

Fowler simply removed the patella; the result was good.

Ridlon and Thomas caused hypertrophy of the external condyle by blows with a mallet.

Wright, Le Dentu, and Chevrier performed plastic operations on the capsule.

Aldebert did an osteotomy, combined with folding of the inner part of the capsule, and enlarged the trochlear surface by chiselling.

Pollard chiselled the trochlea, and excised the inner part of the capsule.

Roux cut away the insertion of the vastus externus from the patella, and transplanted the insertion of the ligamentum patellæ farther inwards on the tibia.

Casati pegged the patella on to the inner portion of the tibia.

Trendelenburg elongated the external condyle by making an aperture

with a chisel, and inserting an ivory wedge, and then did a MacEwen's osteotomy. Lucas Championnière opened the joint, and gouged out a space on the inner condyle to take the patella, and sutured it firmly in place.

Congenital Dislocation of the Ankle-Joint (see p. 211)

Congenital Dislocations of the Bones of the Foot

Luxation at the calcaneo-astragaloid joint is met with in monstrosities, and occasionally is seen when the bones of the legs are defective or absent. Complete luxation is unknown.

A partial displacement internally of the scaphoid is a very usual complication of congenital talipes calcaneo-valgus and equino-valgus. It usually yields to manipulation, splinting, and apparatus. If, despite this treatment, it is persistent and interferes with wearing a flat-foot pad or a Whitman's brace, we have had no hesitation in chiselling off the prominent piece of bone.

CHAPTER V

CONGENITAL DISLOCATION OF THE HIP

History—Frequency and Occurrence—Anatomy—Varieties—Ætiology—Theories of Causation—Symptoms, Diagnosis, and Prognosis.

In congenital dislocation[1] of the hip the head of the femur is partially or completely displaced from the acetabulum. The displacement is not traumatic, nor is it due to disease of the joint, but it originates in a congenital malformation of the parts, which results in loss of stability of the joint.

The actual dislocation may take place during fœtal life, at birth, or in infancy. The occurrence of dislocation in infancy is not conceded by certain writers, but it has been observed in cases where dislocation on one side has led to careful clinical and skiagraphic examination of both limbs. It is then seen that while dislocation exists on one side, the other side is normal. The affected side has been reduced and fixed in abduction. It has been found that dislocation has occurred subsequently on the sound side. This is due to the fact that the limb originally dislocated has been placed in abduction, and therefore the other falls into adduction, and this latter position has been instrumental in producing dislocation in a joint congenitally predisposed thereto. Such a sequence of events has been recorded by Fröhlich and Kirmisson.[2]

[1] The term dislocation has been objected to on the ground that in some cases the surfaces were found to be so deformed that apparently they never could have been in contact, and it was argued therefore that they were never dislocated. Recent researches, however, show that this view is incorrect. The femur and the innominate bone are developed from one mesoblastic mass, and then the joint cleft appears. Therefore intimate contact must have existed at some time.

[2] *Rev. d'orth.*, Jan. 1906, p. 21. Karl Vögel states that dislocation in infancy was so frequently observed at Bier's clinique at Bonn, that it is the custom to include the sound hip in the plaster in a position of moderate abduction.—*Zeitschr. f. orth. Chir.*, 1905, p. 143. Bade says that in about 25 per cent of unilateral cases skiagraphy

It is still under discussion whether the congenital malformation, that is, the condition anatomically favourable to dislocation, is primary or secondary, whether it is a *vitium primae formationis*, or whether it arises from some force external to the fœtus.

Mr. Ralph Thompson, in a thoughtful paper,[1] suggests that "the dislocation may be in reality due to pressure exerted upon the hip-joint during the adoption of the erect attitude, of such a nature as to produce displacement of the head of the normal femur from a nearly normal acetabulum." In fact, that the deformity is partially of static origin, and its greater frequency in females is due to greater weakness of the hip-joint than in males. Mr. Thompson is also disposed to regard many of the changes, which have been regarded as primary and as causes of the dislocation, to be really secondary.

The majority of observers are agreed that the dislocation takes place in early infancy, and that the predisposing factor is an imperfect socket, the exciting factor being the natural movements of the limb in passing from flexion to extension and hyper-extension.

History.—Clinically, congenital hip, as we shall often term it for the sake of brevity, was known to the ancients, but until the nineteenth century its history is of little interest save to the curious. Its pathological anatomy was dealt with by Paletta in 1820, and carefully described by Dupuytren in 1826. From that time the history of its treatment may be dated. In spite of Dupuytren's opinion that no measures could be of any avail, continuous extension was tried. In 1838 Pravaz supplemented extension by abduction and pressure on the great trochanter. Between 1860 and 1870 Pravaz's method was revived by Buckminster Brown and W. Adams. And then came portative extension apparatus, constructed on the principles of the Taylor hip splint.

The history of the operative attempts is briefly as follows:—

Resection of the head of the femur was done by Roser, 1874, and Reyher, 1882. Shortly after this Margary and Heusner attempted to give stability to the false joint by deepening the acetabulum. Poggi, in 1888, forestalled the modern open operation

demonstrates this anatomical predisposition to luxation to exist on the sound side.—Wiener, *Klin. Rundschau*, 1900, Nos. 45 to 48.

In a case shown by the author at the Clinical Society (*Clin. Soc. Trans.* vol. xxxii. p. 268), where the history showed that the child was born with apparently normal hips, the probable explanation was that the case was one of this type of congenitally unsound hips becoming displaced in infancy.

[1] "The Etiology of that Form of Dislocation of the Hip-Joint which is generally regarded as Congenital," *Lancet*, Sept. 11, 1909.

by replacing the intact head in the deepened acetabulum. Paci, in 1888,[1] originated reduction by manipulations similar to those used in traumatic cases. His method was further developed and improved by Lorenz, and extension alone has been abandoned. Reduction by stretching of the soft parts and manipulation has led to a great diminution in the number of open operations, with their serious results and high mortality. The open operation referred to is known as the Hoffa-Lorenz operation, which is founded on the procedure of Poggi.

Frequency and Occurrence.—It is the most frequent and the most important of congenital dislocations. The statistics of orthopaedic hospitals do not give a reliable idea of its relative frequency as compared with other deformities. Some cliniques have a special reputation which attracts an undue proportion of cases. Thus Lorenz states that it is more frequently seen than congenital club-foot, but few, if any, surgeons agree with him on this point. Records, however, prove that it is far from rare.[2] The author's statistics of 5079 orthopaedic cases showed that congenital dislocation was met with in 47 patients, viz. 8 males and 39 females.

Little is known about its absolute incidence. Parise, who examined the hip-joints of 332 infants, who died in L'Hôpital des Enfants Trouvés, found it in three cases, while Chaussier met with it once only in 23,293 infants delivered at the Maternity Hospital. It must be remembered, however, that the condition is rarely recognised until the child begins to walk.

As to sex, 88 per cent of the cases are found in girls.

Heredity[3] is a marked feature, both on the male and female side, and in collaterals. The author has on several occasions observed, on inquiring into the family history of his cases, that there has been an alcoholic history, particularly on the mother's side; and Fournier[4] notes its close association with hereditary specific disease. Congenital dislocation of the hip also occurs in conjunction with other deformities, and is frequently seen in monstrosities.

Anatomy of Congenital Dislocation.—The appearances met

[1] *Studio ed osservazione sulla lussazione congenita della anca e sua cura razionale*, 1888.

[2] Bradford and Lovett, *op. sup. cit.* 3rd edition, p. 479, state that 152 cases of congenital dislocation in one or both hips were met with among 6969 patients at the Boston Children's Hospital.

[3] Vogel noted this fact in 30 per cent, and Marath in 40 per cent of cases.

[4] *L'Hérédo-syphilis tardive*, Paris, 1907, p. 195.

with are of two kinds: (*a*) those due to the original malformation,

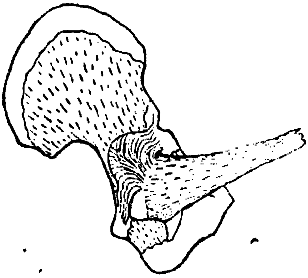


FIG. 105.—The Hip of a still-born child, showing Congenital Dislocation. The upper part of the capsule is thinned out and dilated by the displaced head of the femur (Jackson Clarke).

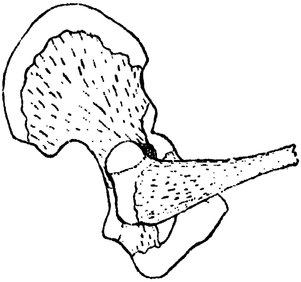


FIG. 106.—The same specimen as in Fig. 105: the Capsule removed (Jackson Clarke).

and therefore congenital; (*b*) those due to subsequent use of the malformed parts, and therefore acquired.

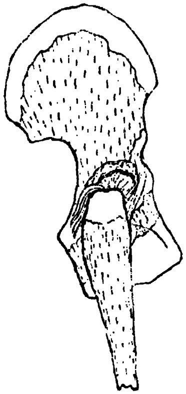


FIG. 107.—The same; the dislocation reduced, and the thigh extended (Jackson Clarke).

It is of the greatest importance to appreciate the conditions usually present at birth, but the number of specimens taken from the newly born and adequately described is not large. This is explained by the rarity of the condition, the facts that there is no immediate fatality attending it, and that it is usually not recognised until walking commences. An undue proportion of the specimens describing the conditions at birth have been obtained from fœtuses rendered non-viable by other grave anomalies,[1] so that it must not be too readily assumed that the hip condition is exactly similar to that which obtains in cases where no other developmental anomalies exist.

We may at once say that the degree of anomaly met with varies from a condition of the parts almost normal to one of deformity so extreme, that it is difficult to believe that at any period of fœtal

[1] An article dealing with congenital hip-joint, with other congenital deformities, by G. A. Wollenberg, will be found in *Zeitschr. f. orth. Chir.* xv. p. 1. He gives over sixty references. Those bearing on the question under discussion are: Graewitz, *Virchow's Arch.*, 1878, Bd. lxxiv. Ht. 1; Holtzmann, *ibid.*, 1895, S. 272; Delanglage, *Rev.*

life anything approaching the usual conditions can have been present. It is impossible to discuss all the varying degrees of misdirected development, descriptions of which are scattered throughout surgical literature.[1]

The *head* may be completely dislocated and displaced into a posterior or anterior position. It may be subluxated, and placed *à cheval* on the posterior border of the acetabulum. Or, in some instances the head is nearly in its normal position opposite the acetabulum, the condition of which is favourable to the luxation which occurs later. That is to say, in the majority of cases

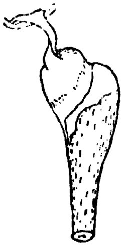


FIG. 108.—The same: the head of the femur and the ligamentum teres from behind (Jackson Clarke).

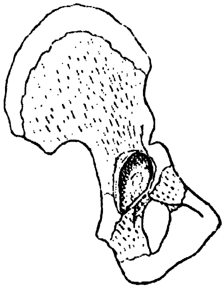


FIG. 109.—The same: the os innominatum and the acetabulum (Jackson Clarke). Note the ovoid shape of the acetabulum.

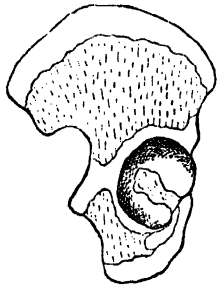


FIG. 110.—Normal Os Innominatum at birth, for comparison (Jackson Clarke).

congenital dislocation is a condition of malformation, the results of which are latent in the early months of life. In the majority of cases it is not appreciable at birth, and only becomes so about the twelfth or fifteenth month when the child begins to walk.

When actual dislocation is present at birth, it is difficult to say at what period of intra-uterine life it originated. Heusner records a bilateral dislocation in a five months' fœtus from an extra-uterine pregnancy, and a unilateral one in a fœtus, ten inches long.

The following conditions are seen in the *fœtus* and *newly born*.

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mens. des mal. de l'enfance, May 1897; Froning, *Case of Congenital Dislocation of the Hip in an Eight Months' Fœtus*, Inaug. Diss., Kiel, 1899; Lockwood, *Path. Soc. Trans.* vol. xxxviii.

[1] Some of the most important are the following:—R. Sainton, Thèse de Paris, 1893; Kirmisson, *Rev. d'orth.*, July 1905; Potocki, *ibid.*, July 1905; Lépage and Grosse, *ibid.*, 1901, p. 257; Caubet, *Arch. méd. de Toulouse*, March 15, 1907; Heusner, *Zeitschr. f. orth. Chir.*, 1902, Bd. x. Heft 4, especially valuable; Jackson Clarke, *Brit. Med. Jour.*, Sept. 30, 1905, and vol. i., 1899, p. 1028.

Speaking generally, the specimens tell us that the *acetabulum* is somewhat small and flattened.[1] Jackson Clarke[2] has described it as small and pear-shaped (Fig. 109); Lorenz says that the margins are less prominent than normal, especially the upper one. This is a point of special importance, and is well seen in the illustration appended to Caubet's article[3] (Fig. 111). The acetabulum, when not occupied by the head, is more or less filled with fatty connective tissue. The *joint-capsule* is elongated and thin (Fig. 112), and the ligamentum teres is generally present, but modified. The pelvis around the capsular ligament is as a rule approximately normal, as is well shown in the illustration from a full-term fœtus in Bradford and Lovett's *Orthopedic Surgery*[4] (Fig. 113). The arrangement in Potocki's cases[5] is worthy of note. The articular cavity was divided into two portions. The upper, or new acetabulum, in which the head rested, was limited above by the insertion of

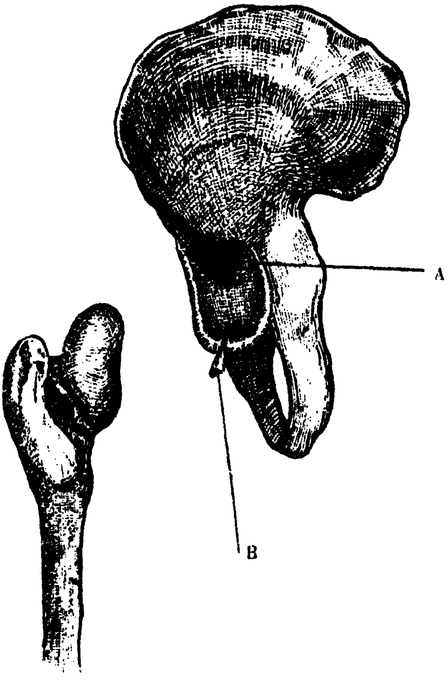


FIG. 111.—Congenital Dislocation of the Hip in a newly-born Infant. The dislocation was upwards and backwards. The upper and posterior margin of the acetabulum is feebly developed, and the cotyloid ligament is entirely absent for a distance of 10 mm. in that situation. The hyaline cartilage is absent, A. from the upper and posterior parts of the cotyloid cavity. The ligamentum teres, B. is rudimentary. The head of the femur is atrophied, deformed, and too small to fit the acetabulum. It is flattened transversely and is conoid in shape. The neck of the femur is nearly vertical (Coxa Valga) and is incurvated with its concavity forward (H. Caubet).

[1] In one of Heusner's specimens the heads of the thigh-bones were dislocated on both sides, yet on one side the acetabulum was practically normal.

[2] *Congenital Dislocation of the Hip-Joint*, Baillière, Tindal, and Cox, London, 1910, pp. 7-10.

[3] *Rev. d'orth.*, Sept. 1, 1906.

[4] Third edition, p. 483.

[5] *Rev. d'orth.*, July 1905.

the capsular ligament into the ilium, and below by the cotyloid margin. It was not lined by articular cartilage. The reflected tendon of the rectus was inserted very high on the external

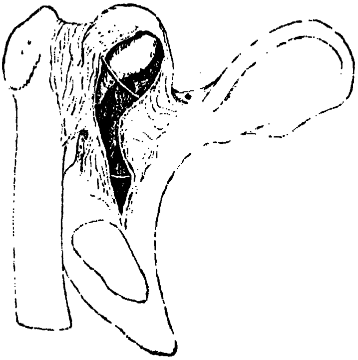


FIG. 112. A dissection of a Congenitally Dislocated Hip. The neck of the femur is varoid, the head is anteverted, and the capsule is hour-glass in shape (Jackson Clarke, after William Adams).

FIG. 113. The side of the Pelvis and Hip-Joint, the capsule having been removed, from a full-term fœtus with Congenital Dislocation of the Hip. The structure of the pelvis in the neighbourhood of the acetabulum is nearly normal (Bradford and Lovett).

surface of the iliac bone, above the displaced capsule. The new depression for the head was thus intra-articular, the capsule being not merely cowl-like over it, but originating higher up.

Finally, the *pelvis* on the affected side may be atrophied, the iliac bone more vertical than normal, with the ischium everted. The latter points are sometimes overlooked in discussing the causation of the pelvic changes seen in older subjects suffering from congenital displacement. It appears that in all cases some form of acetabulum is found, but its shape, depth, and capacity are extremely variable. The head of the femur is as a rule normal in shape, but is sometimes small.

In *post-natal* life additional changes are induced. The mere extension of the limb during or after birth may further displace the subluxated head; and when weight is put on the limb, the head continues to travel, until it is stayed by the resistance of the bony

or soft parts. Secondary changes will be met with in all the structures involved, and these are of two kinds: (*a*) Atrophy arising from disuse in some, and (*b*) Adaptative changes in others. Further, in the same structure, sometimes one, sometimes the other type of change is met with. Thus the ligamentum teres gradually disappears as a rule, but occasionally it may persist and become much hypertrophied.

FIG. 114.—Congenital Dislocation of the hip with alteration in the shape of the acetabulum and in the head and neck of the femur (Bradford and Lovett).

Dealing with the several structures, the appearances in childhood[1] are as follows:—

The Acetabulum.—In the majority of cases it is originally fairly well formed, but as time passes on, departures from the normal become more marked. The results of old-standing traumatic dislocations, and the facts collated with reference to ne-arthrosis and pseudarthrosis in disease leave no doubt as to the effects of contact and function in modelling the shape of the normal articular surfaces. If the femoral head is not in the acetabulum, neither structure will develop normally. The cavity gradually becomes

[1] The changes after childhood, being of little practical interest, will receive only brief mention.

obliterated by the failure of development of its margins, and by the thickening and elevation of its floor (Fig. 114).

Lorenz states that up to ten years of age the decrease in size of the acetabular cavity is more or less concentric, but it still retains its rounded form. It loses in depth more quickly than it does in diameter. Later on, the rounded shape is lost, and the acetabulum becomes a triangular depression, with its apex in front and below,

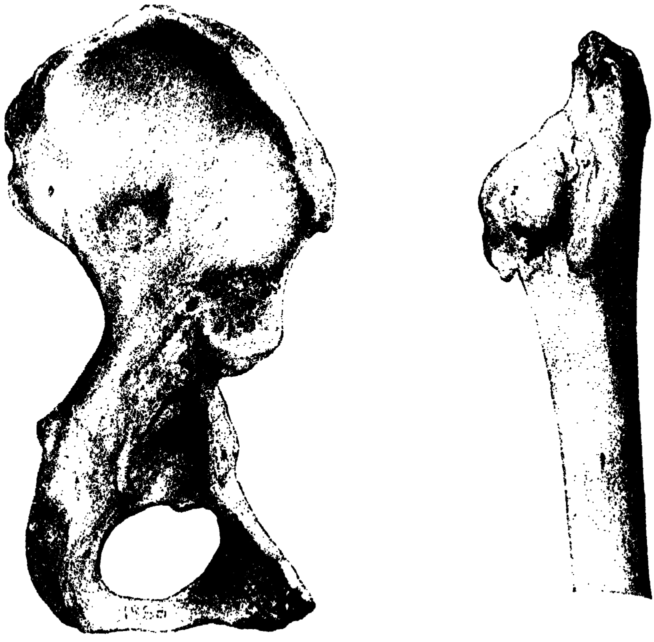


FIG. 115.—Congenital Dislocation of the Hip in adult age, showing the abnormal shape of the acetabulum, the depressions on the ilium caused by the pressure and friction of the head of the femur, and the destructive effect of this pressure and friction upon the femur (Whitman, after W. Adams).

and its base above and behind. Up to twenty years of age, therefore, complete absence is as rare as is complete development.

At first the cartilaginous elements show more profound changes than the osseous, and ossification at first is but slightly modified, a point held by some to militate against the theory of a primary developmental error as causative.

In course of time the acetabular floor is thickened by hypertrophy of the osseous elements (Fig. 115), and this change also extends to the articular cartilage, so that the cavity becomes more

or less filled up. Accompanying this process a prominence is frequently seen on the internal aspect of the bone opposite the acetabulum. This projection into the pelvic cavity can be made out by rectal examination, and is sometimes seen in a skiagram. Minor abnormalities in ossification, and alterations in the acetabular margins, may cause the cavity of the acetabulum to become irregular. The acetabular margins and the cotyloid cartilages are most deficient above and behind, but more nearly normal in front and below.

In a skiagram of a normal acetabulum (Plate X.) a right angle or shelf exists at its upper part (A, Fig. 116). This angle is much reduced in the acetabulum of congenital dislocation, the external surface of the ilium and the floor of the acetabulum tending to come into a straight line, interrupted only by a small projection at the posterior and upper part of the cavity (B, Fig. 116).[1] Even if the head of the bone is in the shallow acetabulum, it is probable that very slight force will push it out.

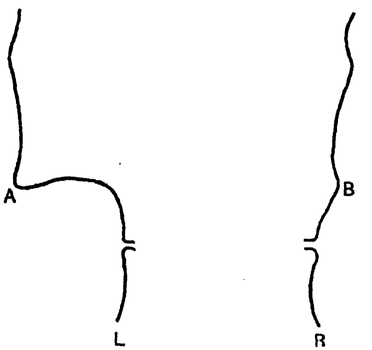
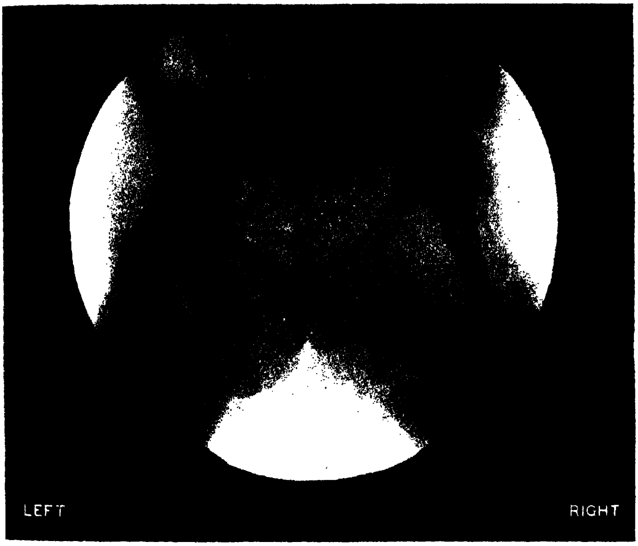


FIG. 116.—Diagrammatic outline of the sides of the pelvis in Plate X. At A, on the left side, the normal right-angled projection or shelf contrasts with the sloping line on the affected side, and the small projection at B.

The acetabular cavity is rendered shallow both by the thickening of its floor and the deficiency of its margin. Its contents are overgrown cartilage, the fatty and fibrous remains of the ligamentum teres and of the Haversian gland, the whole being covered in by the anterior portion of the capsule, which is more or less adherent to the floor of the cavity. This filling up of the acetabulum may be gauged in skiagrams, after the head of the femur has been reduced to the acetabular level, by the width of the light band between the shadow of the pelvis and that of the head. This is in contrast with the normal condition, for, when the head is ossified

[1] Hoffa and Bade (*Zeitschr. f. orth. Chir.*, 1905, p. 143) first called attention to the fact that in unilateral luxations the skiagram very often shows the joint on the other side, the clinically "sound" joint, to be pathologically altered. The head is deformed, the acetabulum is shallow, and a predisposition to luxation is present. The difference between the joints is purely quantitative, the "sound" joint is on the point of being luxated, and becomes so when the necessary trauma is applied.

PLATE X.



Skiagram of the Pelvis and Hip Joints from a child with Congenital Dislocation of the Right Hip. Note the loss of the normal right-angled outline of the upper part of the right Acetabulum, the Narrowing of the Pelvis, the position and direction of the head of the right Femur, and the commencing formation of a False Acetabulum.

To face page 156.

no light band shows at all, the shadow of the rim of the acetabulum blending with and embracing that of the head.

In old-standing cases the acetabular contents atrophy and become periosteum-like.

The Formation of a New Acetabulum.—In the presence of such a condition of the acetabulum proper, what are the prospects as to the spontaneous formation of a new one? The longer the head of the femur is in apposition with a given spot on the innominate bone, and the more intimate and stable the contact, the greater will be the effect on both bones. The head of the femur will be flattened and the iliac bone pressed in. Experimental luxation of the femur in animals[1] may be followed by the formation of a new socket. We must, however, bear in mind that in these experiments the head is brought outside the capsule, while in congenital dislocation in man the head remains inside the capsule. As a rule, therefore, the conditions are unfavourable to the formation of a new joint, because (*a*) the head of the femur does not perforate the capsule, but pushes it in front of it like a hood. There is therefore a fold of capsule left between the bones (Figs. 117, 118, 119). (*b*) When the head has once passed over the acetabular margin, it will slide a considerable distance, on account of the slope of the os innominatum, before coming to rest. (*c*) Close contact between the displaced head and the pelvis is rendered more insecure by the presence of adductor contraction and abductor inefficiency. (*d*) It frequently happens that the neck of the femur is curved with the concavity forwards, so that the head of the bone does not lie "dead on" to the pelvis, but is merely in lateral apposition. (*e*) The body weight is not transmitted through the head of the femur, but is borne by the hypertrophied lower portions of the capsule.

FIG. 117.—Fold of the Capsule between the Head of the Femur and the Os Innominatum. Observe the approximation of the anterior and posterior parts of the capsule, and the narrowing of the entrance to the acetabulum (*Medical Annual*, 1898, after Lorenz).

Still, in spite of all these points, there is sometimes an attempt

[1] Le Damany experimented on a rabbit. Calot, *Congenital Dislocation of the Hip*, p. 64.

at the formation of a new socket (Fig. 120), and in some cases this is so well marked as to give rise to unmistakable appearances in skiagrams [1] (Plate XI.). It is of the greatest importance to grasp the facts, since the success of the so-called bloodless reposition

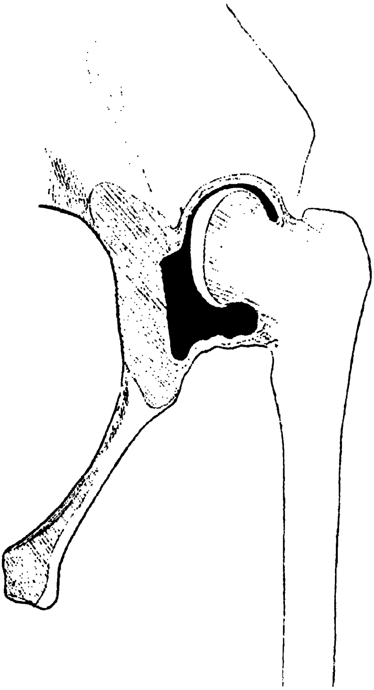


FIG. 118.—A diagrammatic representation of the condition of the capsule frequently met with, its hour-glass shape, and the narrow entrance into the acetabulum (Calot).

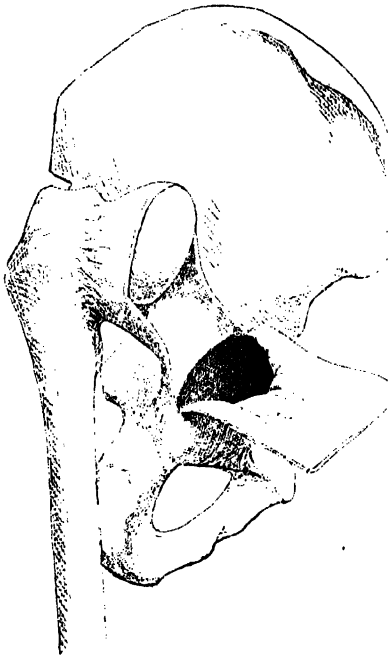


FIG. 119.—From Calot's case of Congenital Dislocation of the Hip, aged 10 years, where the Orifice into the Cotyloid Cavity was exceptionally narrow; and it was found to be impossible to force the head of the femur through the buttonhole by manipulation, so that an open operation was performed (Calot).

depends on the possibility of the femoral head affecting a deepening and a broadening of the original socket, or boring out for itself, as it were, a new socket in the pelvic bone. The prospects are naturally better when the head is replaced either in or over the original acetabulum, as there is less likelihood of a fold of the

[1] See author's case, shown at the Clinical Society, *Clin. Soc. Trans.* vol. xxxii. p. 268; also Calot, *op. cit.* fig. 198; and Blencke, *Münch. med. Wochenschr.*, 1906, xxxiv.

PLATE XI.

Radiogram of a case under Calot's observation, showing the formation of a new Acetabulum on the venter ilii, well above the original socket.

To face page 138

capsule intervening, and contact will be more intimate and stable. If a new socket is formed, it is very doubtful if it ever becomes lined with articular cartilage.

In complete luxations the evidence shows that a new joint, enclosed in its capsule and lined with articular cartilage, does not form. A mere depression, lined with periosteum, is made on the outer surface of the pelvis, and in this depression the femoral head rests more or less insecurely, with the fold of capsule intervening between the bones. In rare cases inflammatory changes cause deposits to be thrown out around the head, and it is then more firmly fixed, but this is an event not to be counted upon. Still more rarely the head perforates the capsule, and a new one forms around it, but this is so lax and weak that the head is not held firmly.

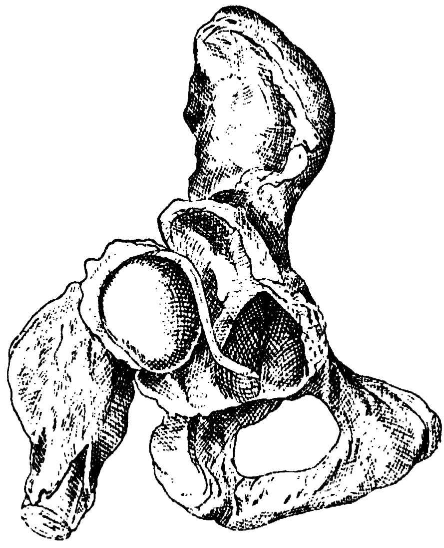


FIG. 120.—Formation of a New Joint above the Acetabulum, which is small and triangular. The attachment of the capsular ligament has been gradually pushed away and up from the margin of the acetabulum so as to surround the greater part of the new joint (Hoffa).

Every effort then should be employed to replace the head of the bone either in the acetabulum or over its site; and if this fail, the head of the bone should be placed as near the acetabulum as possible, and preferably on the margin, so as to reproduce a subluxation.

The Head of the Femur.—Important as is the condition of the acetabulum, that of the head of the femur is still more so. We have seen that the possibilities, so far as the acetabulum is concerned, are considerable, but if the head is badly distorted the difficulties of treatment are almost insuperable. Normally, the caput femoris transmits the body weight, and hence is the fulcrum or pivot around or on which the movements of the limb take place. In congenital dislocation, the body weight is supported by the tension of the soft parts, passing from the trochanteric region

and the base of the neck to the pelvis.[1] It is therefore no longer seriously concerned in carrying the body weight, and it does not act as a pivot. This is readily shown by grasping the dislocated head with one hand while moving the limb with the other in a definite direction. The head of the femur will be felt to travel in the opposite direction to the limb. This is a valuable diagnostic sign.

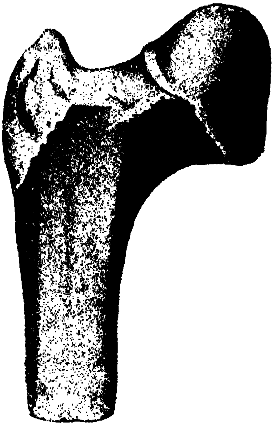


FIG. 121.—A posterior view of the upper extremity of a Femur from a case of Congenital Dislocation in a child, aged 11 years. Note the alterations in the shape of the head, the varoid and anteverted shape of the neck (*Medical Annual*, 1898, after Lorenz).

FIG. 122.—A similar part to that in Fig. 121 taken from a child, aged 14 years. The conditions seen in Fig. 121 are much exaggerated, and the neck of the femur is quite horizontal (*Medical Annual*, 1898, after Lorenz).

The head then is no longer the fulcrum, but is now the short arm of a two-armed lever.

From a functional point of view then the alteration is profound, and is followed by severe structural changes, which, as may be anticipated, are of an atrophic character. The alterations in the upper end of the femur are secondary in character, since it is as a rule normal at birth. In an old unreduced dislocation the head becomes conical and the neck short, while the upper end of the thigh bone generally is atrophic and smaller than normal.

[1] In cases where any attempt at formation of a new joint is absent, a portion of the shaft may come into contact with the innominate bone. In a specimen in the Museum of the Pathological Institute at Königsberg, where no ne-arthrosis existed, the small trochanter has disappeared, and the shaft of the femur is worn through on its inner side to the extent of one-third of its thickness. The part of the innominate bone against which the femur played is hypertrophied, ivory-like, and polished.

Congenital Dislocation of the Right Hip with Extreme Coxa Valga (G. A. Carpenter).

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In examining the upper end of the femur the size and shape should be noted; also the angle which the neck makes with the shaft, and whether coxa valga[1] (Plate XII.) or coxa vara (Fig. 123) is present; and the existence of anteversion or retroversion of the neck should be looked for. The most usual conditions are the small atrophied head, flattened on its median and posterior aspect (Fig. 124), and the short anteverted neck, with its angle diminished. The atrophy may be so extreme that the head is absent.[2] In the case of a girl aged twelve years, who was under the author's care, the head of the femur was very small. It was three-eighths of an inch in diameter, and was placed in a remarkable situation. It was twisted entirely round, so that its convexity looked directly outward instead of inwards. It was accordingly removed, and the upper part of the shaft of the femur was secured to the side of the pelvis, as close to the acetabulum as possible, by silver wire, so placed as to permit flexion. The result was excellent three years afterwards, so far as the stability of the limb was concerned, and there was flexion movement to nearly a right angle.

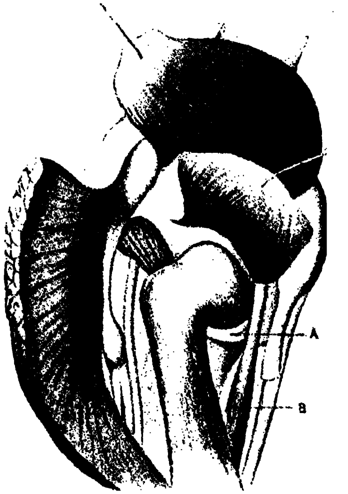


FIG. 123.—Showing the conoid appearance of the head of the femur, and extreme varoid condition of the neck. The Ilio-Psoas Tendon, A, is altered in position, and is a Suspensory Ligament of the Joint. B. Rectus Femoris Muscle (*Medical Annual*, 1898, after Lorenz).

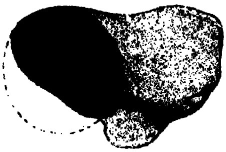


FIG. 124.—Bird's-eye view of the upper extremity of a Femur in Congenital Dislocation of the Hip, showing the flattening of the caput femoris on its postero-internal aspect (*Medical Annual*, 1898, after Lorenz).

When operative interference is undertaken the head of the femur is generally present, but is flattened from before backwards, or otherwise altered. The flattening takes place by attrition on the postero-internal aspect

[1] See author's communication, *Proc. Roy. Soc. Med.*, March 1908.

[2] Lorenz, *Pathology and Treatment of Congenital Dislocation of the Hip*, Wien, 1895. The alterations in the shape and position of the head are well seen in Figs. 121, 122, 123

of the sphere (Fig. 124). This is due to the fact that the neck is usually anteverted or concave forward, and therefore it is the postero-internal part of the head which comes in contact with the pelvis. It is difficult to say whether the anteversion of the neck (Fig. 127) is a primary developmental condition, or whether it is an acquired state arising from the altered relation of the head to the pelvis. If the head is "dead" on the pelvis, that is, the neck is neither ante- nor retroverted, and the limb is normal as regards internal and external rotation, the friction of the pelvis deforms the head into a buffer-shaped object. In some cases it becomes changed into a mushroom-shaped mass; and Lorenz likens it to a much-used hammer, whose striking surface has become spread out, and turned up around the rest of the head (Fig. 125). The articular cartilage is seen to be fairly well marked on those parts of the head which remain in contact with the capsular ligament. Where friction takes place between the bones, it generally disappears.

FIG. 125.—Extreme Deformity of the head and neck of the Femur. The head has become mushroom-shaped, and the neck is extremely varoid (*Medical Annual*, 1898, after Lorenz).

The *Neck of the Femur* is as a rule shortened, depressed, and anteverted (Fig. 123). Sometimes the shortening is so extreme that the head appears to be directly applied to the upper portion of the shaft. Shortening of the neck invariably implies diminution in the length of the whole limb. When the head is depressed, and the neck is anteverted, a condition of coxa vara is produced.

The anteversion of the neck is of the greatest practical importance (Figs. 126, 127). Normally, the angle which the axis of the neck makes with the transverse axis of the condyles is about 12°. That is, the head does not look directly inward, but a little forward as well. In congenital dislocation, when the limb is placed so that the patella is directly forward, the head may look in the same direction. That is, owing to the anteversion or concavity forward of the neck, the head has been twisted forward even to as much as 90°. The actual displacement of the head is chiefly due to bending of the neck, and the latter seems to come off directly from the front of the shaft instead of from the inside. But, to a lesser extent, torsion of the shaft exists, the outer surface of the trochanter looking somewhat backward. The practical deduction is that in order to bring the head completely within the

acetabulum the thigh must be rotated inwards until the patella looks entirely inwards. We shall frequently refer to this point under treatment.

Occasionally, instead of depression of the neck, extreme straightening is met with, and coxa valga [1] exists (Plate XII.).

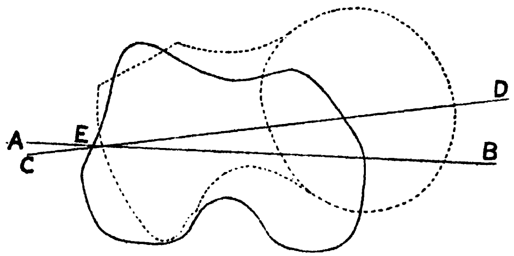


FIG. 126.—A bird's-eye view of the upright Left Femur, showing the head and neck (in dotted lines), and the outline of the condyles (continuous lines). The angle which the axis C D, of the head and neck, makes with the transverse axis of the condyles A B, is normally 12°. This is the angle of declination or the normal anteversion.

Coxa valga, associated with congenital dislocation, has been noted by Schede, Henson, G. A. Carpenter, and the author: it is the exception and not the rule.

Modifications in the Pelvis.—The nature of these depends

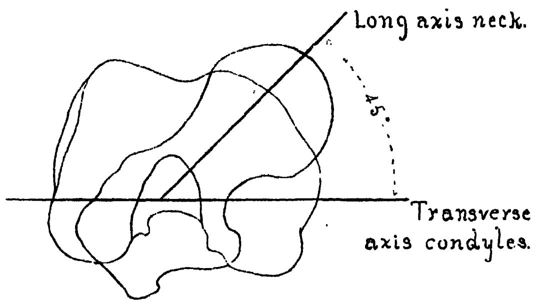


FIG. 127.—Anteverted Twist of the Femoral Neck in a Congenitally Dislocated Femur (Bradford and Lovett).

upon whether the dislocation is unilateral or bilateral, and the position which the head of the femur takes.

In the usual double dorsal dislocation the changes are more or less symmetrical in character. A sagittal section of the pelvis

[1] Drehmann, "Beitr. z. Lehre der Coxa Valga," *Zeitschr. f. orth. Chir.* Bd. xvi. Hefte 1 and 2; and Bd. xvii. Cf. author's cases, *Trans. Roy. Soc. Med.*, March 1908.

shows that it is tilted forward, the sacral promontory directly overhanging the symphysis, that is, the plane of the pelvic inlet makes an angle of nearly 90° with the horizon instead of the normal 45° to 60°. The result is that there is a great increase of the natural lumbo-sacral lordosis, and careful measurements show that this change takes place chiefly in the fifth lumbar and first sacral vertebræ and in the intervening disc. The sacrum itself is tilted out and greatly curved.

If the pelvis be regarded from the front, the innominate bone is situated more vertically (Fig. 128), and the iliac crests are nearer together than normal. The anterior inferior iliac spines are placed more directly under the anterior superior, and the ischial tuberosities are everted. The cause of this eversion is said to be a tension on the muscles passing from this region to the upper end of the femur. They, with the anterior portion of the capsule, act as suspensory ligaments of the weight of the body. Between the anterior inferior spines and the ilio-pectineal eminences, deep depressions are seen. These are the psoas grooves.

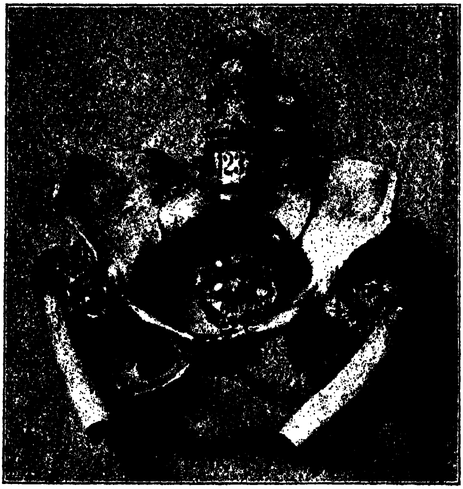


FIG. 128.—The Pelvis from a woman, aged 45 years, with Bilateral Congenital Dislocation of the Hip. Compare this figure with the description in the text (Lorenz and Max Reiner).

Finally, the whole of the innominate bone is somewhat small and atrophied. From an obstetrical point of view the changes in the pelvic cavity are of little importance. The transverse diameters, both at the brim and outlet, are increased, and that of the conjugate is diminished, so that the inlet becomes transversely ovoid.

In unilateral cases these brief remarks on the pelvis require modification. The pelvis is not so much tilted antero-posteriorly, but is now laterally inclined, and the shape of the pelvic inlet is obliquely ovoid.

The Soft Parts. (*a*) *The Capsule.*—As we have stated, the head does not perforate the capsule, but stretches and distends it, so that the uprising head is covered by a hood of the capsule (Fig. 118), and between the head and the pelvic bone, in old-standing cases, the capsule becomes contracted or hour-glass in shape (Fig. 142, p. 169). This is largely due to the tendon of the ilio-psoas passing across the capsule from before backward, to be inserted into the trochanter minor (Figs. 123 and 142, pp. 141, 169). This contraction of the capsule is by no means an insuperable obstacle to reduction in early life. The condition is that of an unstretched finger of a glove, a very slight distending force being capable of opening it out. Through the constriction the round ligament, when present, passes. There is, however, a second narrowing of the capsule, which when present is often a permanent hindrance to reposition. As the head of the femur is displaced more and more upward and backward on the ilium, the strong anterior portion of the capsule gets nearer to the posterior acetabular margin; and, becoming contracted, is stretched tightly across the entrance to the acetabulum, from its posterior aspect. With continuous contraction, the aperture leading from the distended capsule into the true acetabular cavity may be reduced to a small buttonhole (Figs. 119 and 143, pp. 138, 170). In still more marked cases the anterior wall of the capsule blends with the remains of the soft tissues of the acetabular floor, and the cavity is thus actually obliterated, its site being covered over by the outspread attachments of the anterior layer of the capsular ligament.

In congenital dislocation the capsule becomes a suspensory ligament, and a functional hypertrophy, most marked at the anterior and lower portion, is seen. It may here be as much as one centimetre thick. Finally, it may be blended with the degenerated gluteus minimus where it is in contact with that muscle.

The ligamentum teres is normally a very variable structure. In congenital dislocation it may be entirely absent, or, if present, it is variously altered. Sometimes it is thinned or even worn away entirely; at other times it is hypertrophied. As a rule the ligament is present up to three years of age, but after four years of age it disappears. As the ligamentum teres serves to transmit a small nutrient artery to the head of the femur, its disappearance may be an additional reason for the atrophy of that structure.

The Muscles.—The condition of the muscles acting on the hip-joint calls for the closest examination. It is obvious that in

congenital hip there is after all not so much in the state of the bones to prevent reposition, but the difficulty of keeping them so is another matter altogether. The changes in the capsule cannot necessarily prevent the head being brought on a level with the acetabulum. Yet, even in early cases, it is a matter of common knowledge how difficult it often is to get the head of the bone opposite the socket, and the cause is almost entirely the state of the muscles. Lorenz very conveniently divides these into three groups:—(1) Pelvi-trochanteric group; (2) Pelvi-femoral group; (3) Pelvi-crural group.

We will take the last, the *pelvi-crural group*, first, as the changes in these are the least complex. This group comprises the hamstrings, the gracilis, the pelvic portion of the rectus femoris, the sartorius and the tensor vaginæ femoris, and a large portion of the adductors. They run approximately parallel to the long axis of the limb, and if the limb is shortened, the slack is taken up to a corresponding extent, first functionally, then structurally. Their direction is not much altered; but the shortening is a great obstacle to reduction. The difficulty may be overcome by division of the adductors and the hamstrings previously to the operation, or, in children who have not walked, by preliminary weight-extension for several weeks; or possibly the effects of shortening may be neutralised by flexion of the limb at the knee and hip-joints during reduction by manipulation. But even if these muscles are thus relaxed, and the dislocation reduced, on straightening the limb the deformity will reappear.

The author finds it better to divide the adductors freely by the open method at a preliminary operation, and then apply weight-extension for some weeks.

The effect of dislocation on the action of the muscles is represented by Fig. 129 taken from Lorenz and Reiner's work.

The diagram lends itself less to bringing out the salient points of the pelvi-crural group, than to those of the others, as the parallelism with the long axis of the limb is much closer than is here suggested. The point, however, that shortening is the chief change, while alterations of direction and function are relatively slight, is clear. It is evident, then, that the pelvi-crural group will form a great obstacle to reduction, an obstacle which may be in part overcome by flexion of the limb at the knee and hip-joints during manipulation; but of course even were they thus relaxed, and the dislocation reduced, the deformity recurs on straightening the limb.

Considerations in the case of the *pelvi-trochanteric* muscles are

less simple. This group may be divided into a superficial and a deep layer. The superficial set comprises the glutei, and a deeper set, the obturators and quadratus femoris, and further includes the psoas tendon. It is impossible to deal here with the individual muscles at length, but general changes may be mentioned.

If the trochanter were displaced directly upward, the muscular fibres passing from the highest point of the iliac crest to it would be shortened. The trochanter, however, is displaced not only upward, but outward, so that a lengthening factor is introduced which more or less neutralises the shortening. The quadratus femoris, which passes from the pelvis into the trochanteric region, will be lengthened if there is much shortening of the limb; but if there is much rotation outwards this lengthening will be compensated by the approximation of the posterior border of the great trochanter to the ischium.

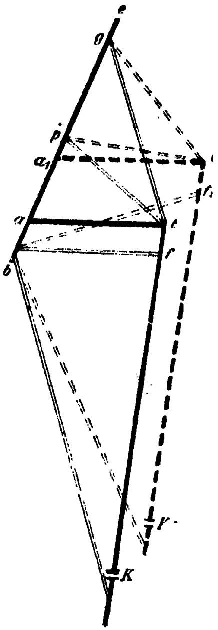


FIG. 129.—Schema of the Muscle-Groups. *eb*, side of the Pelvis; *a*, normal and a_1, new position of the Head of the Femur; *t*, normal and t_1, new position of great Trochanter; *gt*, normal direction, and gt_1, new direction, of gluteal (Pelvi-trochanteric group); *pt* and pt_1, Pyriformis; *qf* and qf_1, Quadratus femoris; *qK* and qK_1, hamstring muscles (pelvi-crural group); *K* and K_1, Knee-Joint (Lorenz).

The fibres of the gluteus medius and minimus radiate fanwise, and considerations which apply to the vertical fibres cannot do so to those running horizontally. Further, the fact that these two muscles are stretched over the prominent and dislocated head introduces a lengthening element. On the whole, therefore, neither theoretically nor practically can anything like a general shortening of this group be shown, and Hoffa's procedure of dividing these muscles in the trochanteric region loses its *raison d'être*.

But while no general shortening exists, the displacement induces a condition of marked functional impotence, especially of the glutei. This is shown by the inability of the patient to steady the pelvis, when standing on the affected limb. The pelvis drops on the sound side. This is known as Trendelenburg's sign, and its constant repetition in walking is one of the causes of the characteristic and ungraceful

waddle in this affection (Fig. 130). In coxa vara, the reverse obtains (Fig. 131). When the patient stands on the affected limb, the pelvis is raised on the sound side.

A few words must be added about the gluteus maximus and the psoas. Normally, the gluteus maximus passes downward and outward, covers the ischial tuberosity and the great trochanter, and its lower border gives rise to the internal portion of the fold of the nates, the outer portion of the fold being of cutaneous and subcutaneous origin, and crossing the muscle obliquely. In congenital dislocation, owing to the shortening of the limb and the elevation of the insertion of this muscle, its fibres become less oblique and more horizontal. Therefore the level and direction of the fold of the nates is changed. The elevated trochanter also, while still covered by the gluteus medius and minimus, projects above the upper border of the gluteus maximus, and its contour is more readily felt beneath the skin. The ischial tuberosity is more or less uncovered by the upward elevation of the lower fibres of the muscle.

Fig. 130.—Trendelenburg's Sign—Congenital Dislocation of the Left Hip. The pelvis drops on the sound side (Right) when the patient stands on the affected limb (Left) (Bradford and Lovett).

Fig. 131.—Coxa Vara—Trendelenburg's Sign is reversed. The pelvis is elevated on the sound side (Left), when the patient stands on the affected limb (Right) (Bradford and Lovett).

The psoas muscle with the tendon undergoes important changes in direction. As it crosses the brim of the pelvis it is displaced outward. It projects, and tends to get beneath the anterior inferior spine. It then winds outward and backward, compressing the capsule, and passes to its insertion. Three points are to be noted. It stretches from the trochanter minor to its vertebral origin like a

sling, and on it the pelvis rests. It is thus a suspensory ligament for the body weight (Fig. 142, p. 169). The tension, thus set up in it, leads to dragging forward of the lumbar spine, and partly accounts for the lordosis. And, finally, its displacement outwards as it crosses the pelvic brim under Poupart's ligament, leaves a weak place through which a crural hernia may descend. The hernia thus induced is not the ordinary femoral hernia, which passes through the femoral ring internally to the vessels. It is one which escapes beneath Poupart's ligament, and over the vessels, filling the gap left by the outwardly displaced muscle (Narath's hernia).

In my experience of open operations for congenital dislocations, I have found that the psoas tendon offers a very great obstacle to the reduction of the head of the bone into the acetabulum. Both it and the lower fibres of the capsular ligament can be localised as extremely tight, firm bands passing backward and downward beneath the head. They require free division before the parts can be replaced, and, I find, constitute one of the chief causes of relapse after the operation. In dividing the psoas tendon the knife must be kept very close to the bone to avoid wounding the internal circumflex artery, which passes backward between the psoas and the pectineus.

From the previous considerations the state of the *pelvi-femoral* group can be readily deduced, and little requires to be said. The lower portion of the adductor magnus is shortened, like the pelvi-crural muscles, and therefore it is often found expedient in the preliminary tenotomy of shortened muscles to divide the tendon just above its insertion into the lower part of the inner side of the femur. The upper part of the adductor magnus is not much shortened, but its fibres become more oblique in consequence of the elevation of the head. The adductor longus also undergoes shortening, while in the adductor brevis the change is merely one of direction.

To sum up the condition of the muscles from a practical point of view. Those which prevent the head of the femur being brought down to the level of the acetabulum all originate, except the ilio-psoas, from the pelvis, and are inserted below the middle of the femur. They include the hamstrings, the rectus, the tensor vaginae femoris, and a large portion of the adductors. These muscles constitute the pelvi-crural group, while the influence of the muscles of the other groups, except that of the ilio-psoas, is slight. Happily we are enabled to combat the shortening of the pelvi-crural group

by tenotomies, open or otherwise, at the inner side of the thigh, just below the symphysis pubis; and at the outer side of the thigh, just below the anterior superior spine; also at the inner side of the knee, where the adductor magnus and inner hamstrings can be divided. The tendon of the ilio-psoas can only be reached by a deep and somewhat difficult dissection, and we have to rely upon preliminary extension and forcible stretching at the time of reduction to overcome the contraction in most cases.

Varieties.—The dislocation may be complete or incomplete. Incomplete is partial dislocation, and is merely a stage on the road to complete. The deformity may be unilateral or bilateral. As to the relative occurrence on one or both sides, the figures given by Bradford and Lovett[1] are—of 341 cases, 122 were bilateral, 95 were right-sided dislocations, and 96 were left-sided. Whitman[2] quotes the following: "Hoffa collected 1362 cases, 502 were bilateral, and 860 were unilateral, viz. 392 on the right, and 468 on the left side." Whitman also gives statistics from his own hospital of 801 cases: 231 were bilateral, 206 were right- and 353 were left-sided, and in the remainder these details are not specified.

FIG. 132.—Forward and Upward Congenital Dislocation of the right hip, taken from a girl aged 8 years.

The position of the head varies. If on examination it can be felt from the front below or near the anterior inferior iliac spine, a forward and upward dislocation is present (Fig. 132). If it can be felt posteriorly in the buttock, a backward and upward dislocation exists. Between these two it may be directly upwards or supracotyloid.

Lorenz[3] states that the exceptions to the above are quite negligible, and are referred to only for the sake of completeness.

[1] *Orth. Surg.* 3rd ed. p. 479. [2] *Ibid.* pp. 515 and 516.

[3] *Pathology and Treatment of Congenital Dislocation of the Hip*, translated by F. Collet, p. 33.

Recently the tendency has been to extend the classification. Lange speaks of a *luxatio supracotyloidea, luxatio supracotyloidea et iliaca* and *luxatio iliaca.* Hoffa speaks of dislocation (1) directly upward, (2) upward and outward, (3) upward and backward, (4) outward from the inferior iliac spine. We do not propose to go into these in detail, as it would take up too much space and be a needless complication. Nevertheless, in any case, whatever be the original direction of the dislocation, the tendency is eventually towards the iliac or upward and backward variety.

In the anterior form, which at one time was regarded as a rarity, but has been shown to occur comparatively frequently, the limb is always shortened, but less so than in the posterior form. In the forward and upward variety the head can be made out from the front lying externally to the femoral artery, or at any rate is so displaced outwards that the artery does not pass across the centre of the head of the femur.

Ætiology.—At the present time two theories of causation call for discussion. There are many others, but they do not merit serious consideration. The two theories that we shall discuss are (1) That congenital dislocation depends on a developmental anomaly of the parts concerned; (2) It is due to uterine pressure, acting on the flexed fœtal limb, forcing the femoral head against and over the rim of the acetabulum.

The points in favour of the first theory are:—(*a*) The marked hereditary factor;[1] (*b*) Hereditary transmission is through both male and female parents, and is seen in collaterals; (*c*) The preponderance of girls affected over boys[2] is only to be explained on the general principle that early developmental errors are seen more often in the female and more primitive type; (*d*) The co-existence of other anomalies of development, which so far have not been explained on mechanical grounds; (*e*) The frequency of bilateral occurrence; (*f*) Its occurrence in other members of the same family.[3]

[1] Narath (*Zeitschr. f. orth. Chir.*, 1905, p. 133) met with a history of heredity in 10 per cent of his cases. Karl Vögel found a hereditary factor present in 30 per cent of 200 cases. It passes equally through both the male and female parent. It must be remembered that congenital dislocation is a cause of celibacy in many females.

[2] The percentage of girls affected is said to be 88. It is an interesting fact that the predominance of the female sex is much more marked in the cases of congenital dislocation of the hip and of the knee-joint than in those which are caused mechanically.—*Rev. d'orth.*, Nov. 1905, p. 509.

[3] The author now has three cases under his care, comprising the three children of one family. Each child was found to be affected with congenital dislocation of the hip. In each case dislocation is unilateral and on the left side.

The developmental theory was originally advanced by Verdue, and has been supported by Paletta, Dupuytren, Döllinger, Adams, Lockwood, and many others. But on close consideration certain difficulties appear. We have used the term "a developmental anomaly." What does this mean exactly?

According to von Ammon[1] the early acetabulum is a shallow, saucer-shaped depression, not large enough to contain the femoral head, and in congenital dislocation the former fails to develop *pari passu*. He went so far as to say that in some cases the head had not occupied the acetabulum at all, and therefore dislocation is a misnomer. Lockwood[2] holds much the same view. He writes: "The hip-joint is not at first a pelvic socket, in which the head of the femur lies, but the acetabulum is formed by a growth of pelvic cartilage up and around the head of the femur."

More recent investigations into the manner of development of the hip bone do not confirm this idea. The mesoblast, from which the cartilaginous models of the bones are developed, forms at first an unbroken mass in this region. The researches of Petersen[3] and von Friedländer[4] show that the shape of the articular surfaces is defined before the joint cleft is differentiated, and before rotation of the limb takes place. Recently Karl Vögel[5] has suggested that the cause is a disturbance in the distribution of the blastema of the part, but he has not demonstrated any such occurrence. According to Döllinger, the trouble is caused by premature ossification of the Y-shaped cartilage of the acetabulum, which ceases to grow. As a matter of fact, we now know that such premature ossification is absent. Grawitz's[6] theory, a more likely one than Döllinger's, is that an arrest of development of the Y-shaped cartilage takes place, but satisfactory anatomical proof of this is lacking. The difficulty in the developmental theory is to decide in exactly what way an error has occurred.[7]

The Mechanical Theory.—Intra-uterine mechanical causes afford a tempting field for investigation. The phrase in common use, namely, intra-uterine malposition, is not a very apposite one.

1 *Die angeborenen chirurgischen Krankheiten der Menschen*, Berlin, 1842.
2 *Trans. Path. Soc.* vol. xxxviii., 1886, p. 303.
3 *Arch. f. Anat. u. Physiol.*, 1893.
4 *Zeitschr. f. orth. Chir.* Bd. ix. p. 515.
5 *Ibid.* Bd. xiv. p. 151. 6 *Virchow's Arch.*, 1878, Bd. lxxiv. 1.
7 The following references may be consulted: Lorenz and Max Reiner, Joachimstal's *Handb.* Lief. v. p. 125; Ewald, *Deutsche Zeitschr. f. Chir.* Bd. lxxx. Hte. 3, 4; Wollenberg, *Zeitschr. f. orth. Chir.* xv. 1, pp. 118-150; Karl Vogel, *ibid.*, 1905, pp. 133-159.

It is not that any particularly evil or abnormal position is adopted *in utero*, but that almost any position, if maintained too long, leads to definite results. Now, is there any particular position *in utero* which is likely to cause dislocation of the hip, and, if so, is there any evidence of prolonged retention in this position? That is to say, can we point to prolonged forcible retention[1] in a position likely to cause the dislocation during fœtal life? Lorenz, Hoffa, and Hirsch, noting the readiness with which the acetabulum can be reformed after reduction of the dislocation, argue that no primary developmental anomaly can be present. We do not regard this point as conclusive, but it has led many observers to turn their attention to the mechanical theory, which is briefly as follows:—

The anatomical disposition of the hip-joint depends partly on heredity, since the shape of the joint surfaces is defined even before the joint cleft is formed, and partly on function. Obviously there can be no reciprocal modelling effected, unless the parts are in immediate contact. This is at its maximum in extension and abduction, and at its minimum in flexion and adduction. In other words, the acetabulum covers the head most completely in extension and abduction, and less so in flexion and adduction, and then the head is largely exposed. Now, marked flexion, often with adduction, are common positions of the fœtal thighs. That this flexion of the thighs is sufficiently prolonged and constant to set up slight contraction of the flexors of the hips is evidenced by the common observation that complete extension is impossible in the newly-born child,[2] whilst the intra-uterine attitude is readily adopted after birth.

Not only does prolonged intra-uterine flexion lead to much contraction of the structures on the front of the joint, such as the ilio psoas, but it causes stretching of those situated posteriorly, and it will readily be conceded that flexion and adduction will not only stretch the capsule behind and below, but will also cause the head of the femur to distend it. As the head presses more and more on the capsule in this region, and on the adjoining portion of the acetabular margin, it loses contact more or less with the rest of the socket, with the result that uncontrolled growth and malformation thereof take place.

[1] The expression, "andauernde Zwangshaltung," or "prolonged forcible retention," is much more suggestive than our expression, "uterine malposition."

[2] Mr. Jackson Clarke describes a specimen (*Trans. Brit. Orth. Soc.* vol. i.), in which contraction of the anterior portion of the capsule resulted from intra-uterine flexion, and prevented extension at birth.

There can be no forcible retention in any position unless the fœtus is cramped by want of room. This may be due to deficiency of liquor amnii or amniotic constrictions, the presence of another fœtus, or the abnormal bulk of some part of the affected fœtus itself, as, for example, hydrocephalus.

Apart from the actual occurrence of congenital dislocation occurring under these conditions, certain other evidences of intra-uterine pressure have been observed. Such an one is the coincidence of congenital genu recurvatum,[1] a condition undoubtedly due to the retention of the knee in over-extension; the co-existence of congenital club-foot, which is caused by forcible retention, in many cases; and actual signs of the compression of the fœtal limbs against the body, which have been chiefly seen in thoracic deformities. These are good evidence in favour of the general theory of intra-uterine compression.

We must conclude that, although a very fair case can be made out for the mechanical theory, certain awkward points can fairly be brought against it. If the dislocation were always due to forcible retention *in utero*, we should expect actual dislocation to be present at birth, or, at all events, subluxation, and this does not appear to be the usual condition.[2] Then again, according to the mechanical theory, the dislocation must always be a postero-inferior, which subsequently by extension becomes a postero-superior. Again, in Potocki's case marked hydramnios was present, four litres

[1] Perhaps a better expression is congenital dislocation of the knee. Tridon has collected 121 cases of congenital dislocation forward of the knee, and in no fewer than twenty, congenital hip was present or subsequently developed. He is emphatically of opinion that the bulk of cases of congenital dislocation of the knee are due to intra uterine mechanical causes. Referring to the bearing of these on congenital hip, he says: "As regards congenital luxation of the hip, the majority of clinicians in France adhere with M. Kirmisson to the theory of von Ammon, that is, to the idea of an arrest of development. This is incontestably true, for in a large number of cases of embryonic luxation, truly congenital, the pathological anatomy shows us gross malformations of the cotyloid cavity and the femoral head, and the existence at the site of the coxo-femoral articulation of a kind of fœtal luxation, that is to say, one developed at a much later period of intra-uterine life."—*Rev. d'orth.*, Nov. 1905. *Cf.* "Genu recurvatum droit, accompagné de luxation congénitale de la hanche du même côté," P. Ardouin, *Rev. d'orth.*, March 1907, pp. 193-198.

[2] Heusner brings forward considerable evidence to show that at birth, or even for a considerable time afterwards, no real dislocation exists in the bulk of the cases.—*Zeitschr. f. orth. Chir.*, 1902, Bd. x. Ht. 4. He says that "the joint capsule is sufficiently lax in the fœtus, especially the female, to permit subluxation backward. If the thigh is flexed and pressed downward and backward, the head can be displaced half-way out of the acetabulum." Hoeftmann (*Zeitschr. f. orth. Chir.*, 1906, p. 303) confirms this, and finds that the younger the fœtus the easier is the dislocation produced.

of amniotic fluid escaping when the membranes were punctured, so that uterine pressure on particular parts of the fœtus was impossible.

Against the mechanical theory is the existence of hereditary influence through the male parent or collaterals; and if the coincidence of certain malformations attributable to mechanical causes, such as genu recurvatum, is in favour of the mechanical theory, the coexistence of certain other malformations not to be thus explained goes far to neutralise this evidence. There are many other points which may be advanced against the mechanical theory.

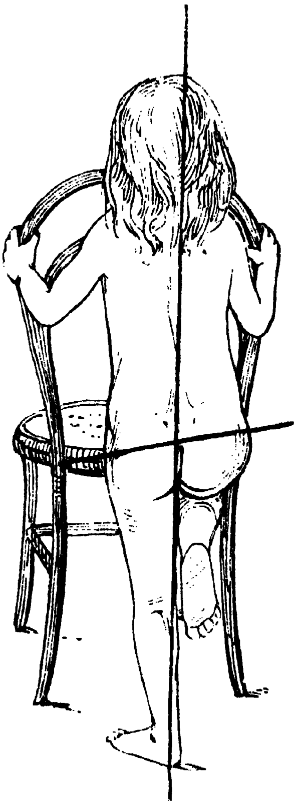


FIG. 133.—The position of the Trunk in a healthy individual when standing on one leg. For explanation see text.

Other theories, of which the briefest possible mention is given, are :—

(*a*) *Intra-uterine traumatism* (Cruveilhier and Petit). In most cases there is no such history.

(*b*) *Trauma during birth*, especially in breech presentations.[1] Against this theory is the fact that in forty-five of Adams's cases the head presented, and the confinement was easy. Experiments show that traumatic dislocation in a normally formed fœtal hip is very difficult indeed to produce, so that crude traumatic theories are quite untenable. And dislocation is not present at birth in every case.

(*c*) *Muscular contraction*, due to some central nervous lesion; no nerve lesion however, has been found.

(*d*) *Paralysis due to anterior poliomyelitis* during either fœtal or infantile life. The anterior poliomyelitis has never been demonstrated in the cord, nor its effects on the limbs.

To sum up the discussion on the theories of causation. The author's opinion is that, owing to an anomaly of development, the acetabulum is defectively developed either in depth or in shape, or the posterior margin is deficient, so that the condition of the parts is unstable, and the movements of the limbs, whether in intra-

[1] Brodhurst, d'Outrepont, and Phelps, *Trans. of Amer. Orth. Assoc.*, 1891.

uterine life, at birth, or during infantile life, are sufficient to displace the unstable head of the femur from the acetabulum.

Symptoms.—*The Gait* in congenital dislocation is a duck-like waddle. To describe it is not easy, and we must consider the factors involved. Walking consists of balancing the trunk alternately on each lower limb. Normally, at each step the trunk inclines towards the active limb, the pelvis being tilted, so that it is lower on that side. The same occurs when a normal individual stands on one leg (Fig. 133). The pelvis and the shoulder are higher on the opposite side, and the spine deviates slightly to the same side. The alternation of these positions from side to side produces the slight undulatory action of the upper part of the body seen in ordinary walking. If we tell a patient suffering from congenital hip to stand on the affected limb, the pelvis drops on the opposite side (Fig. 130). This is due to the functional disability under which the glutei work (Trendelenburg's sign). It is, of course, not pathognomonic of congenital dislocation, but merely indicates gluteal disability, which may be illustrated thus:

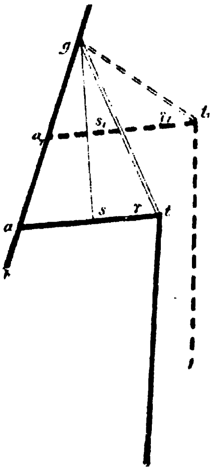


FIG. 134.—Schema to explain the Impaired Action of the Gluteal Muscular Group in Congenital Dislocation of the Hip. The lettering is indicated in the text (Lorenz).

The pull of a muscle is proportional to the sine of the angle made by its line of action with the long axis of the part on which it acts. In Fig. 134 *eb* is the pelvic wall, *at* the normal femoral neck, a_1t_1 the dislocated femoral neck, *gt* the glutei (middle fibres). The pull in the normal position is to the pull in the dislocated position,[1] as—

$$\sin \gamma : \sin \gamma_1.$$

That is—

$$\text{as } gs : gs_1.$$

We are now in a position to attempt an explanation of the extraordinary gait in this condition. When, for example, it is the left hip which is dislocated, directly the patient lifts the right leg the pelvis drops on this side of the trunk, and is also inclined to that side. To obviate this, as the pelvis drops to the right side the trunk is jerked to the left. If it is a case of dislocation on the right side the reverse takes place, and in bilateral dislocation the trunk is drawn first to one side and then to the other.

[1] Provided that $gt = gt_1$, and on this point see the previous discussion as to the state of the pelvi-trochanteric muscles (pp. 147-148).

An important secondary effect of this dropping of the pelvis is seen in the spine. As it is the sound side which is dropped, a long C-curve in the spine is formed on the sound side, and in time this may lead to a scoliosis of the same character. In double dislocation there is no tendency to scoliosis, but the lumbar spine becomes very mobile laterally.

FIG. 135. Bilateral Congenital Dislocation of the Hip—Flexion at the Hips. Severe Lordosis (Tubby and Jones *Medical Annual*, 1898).

In walking also, when weight is borne on the affected limb, the trunk sinks down vertically more or less, and the trochanteric eminence on the affected side appears to rise. The body weight is no longer transmitted through the femoral head, but is suspended by the soft parts, which stretch to their limits, and the skin over the trochanter of the affected side becomes prominent.

The gait is also modified by the limitation of movement induced by adductor contraction, by flexion at the hip (Figs. 135, 136), by lordosis, by flexion of the knee, partly compensatory and partly

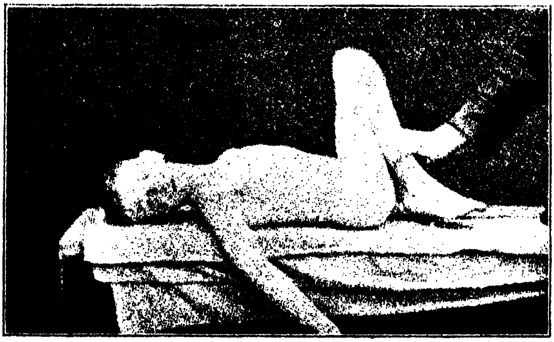


FIG. 136.—The same patient as in Fig. 135, showing the disappearance of the Lordosis on further Flexion of the Thighs (Tubby and Jones, *Medical Annual*, 1898).

due to the tense ham-strings, and perhaps by some equinus of the foot.

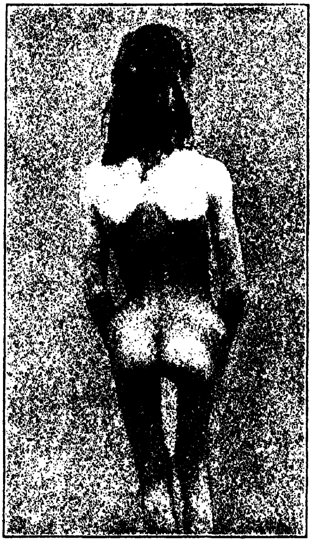


FIG. 137.—Back View of a girl with Bilateral Dislocation of the Hip (Tubby and Jones, *Medical Annual*, 1898).

FIG. 138.—Side View of the patient in Fig. 137, showing Excessive Lordosis (Tubby and Jones, *Medical Annual*, 1898).

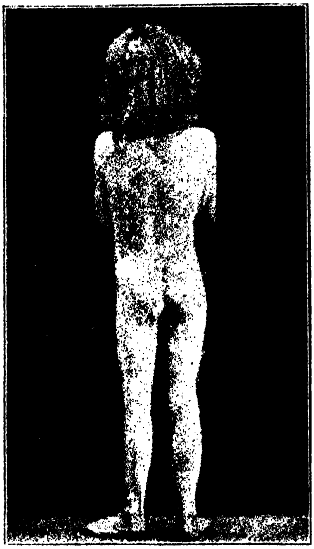


FIG. 139.—Unilateral (Left) Congenital Dislocation of the Hip with commencing Scoliosis, a Lumbar Curve to the Right and a Dorsal Curve to the Left (Tubby and Jones, *Medical Annual*, 1898).

Lordosis.—Lordosis is particularly well marked in bilateral cases, and less so in unilateral (Figs. 137, 138, 139).

The lameness is usually not accompanied by pain, unless the patient becomes fatigued, and the limping can often be voluntarily suppressed, at any rate for a little while.

The history is that the manner of walking was abnormal from the start, and that it became steadily worse.

Deformity.—In unilateral dislocation, if the measurements be taken from the top of the great trochanter to the malleolus, there is as a rule no difference, but when the measurements are taken from the anterior spine the affected limb is found to be shortened. The trochanter is also elevated above Nélaton's line and is prominent. The gluteal fold on the affected side slopes upwards, partly because the skin is stretched over the great trochanter, and partly owing to the fact that the direction of the gluteus maximus is changed.

In bilateral cases the lower limbs appear to be short relatively to the whole body, and the proportion of the length of the thighs to the legs is lost (Figs. 140, 141). The perineal space is widened, the trochanters are prominent, and the buttocks are broad and flat. On palpation the ischial tuberosity on either side is felt to be no longer covered by the gluteus maximus.

Diagnosis.—In many cases no difficulty arises, but hasty diagnosis is to be deprecated, and three definite points must be considered: (1) Is the head out of the acetabulum? (2) If so, where is it? (3) Can the dislocation be due to any cause other than congenital?

As to (1), skiagraphy usually settles this point at once. The normal position of the head is in the groin, below Poupart's ligament, with the femoral artery almost crossing its middle, and in a suspected case it is easy to ascertain by rotating the limb if the head is in the position indicated. If it is not, it can readily be found by careful palpation, the identity of the head being established by the movement of rotation of the limb; and it is to be noted that the excursion of the head in dislocation is in the opposite direction to that of the foot. Further, if the great trochanter has its normal relation to Nélaton's line,[1] it is practically certain that the head is

[1] Too much importance must not be attached to this measurement. Normally the tape passes across the skin at a point corresponding to the centre of the acetabulum. In 43 per cent of infants this is so. But the shape of the iliac bone is very variable, and in the remaining 57 per cent the centre of the socket is not so crossed.—G. Preisel, *Zeitschr. f. orth. Chir.*, 1907, pp. 265-275. Stewart L. M'Curdy has dealt with this subject, and suggests a new measurement. A line is drawn horizontally through the

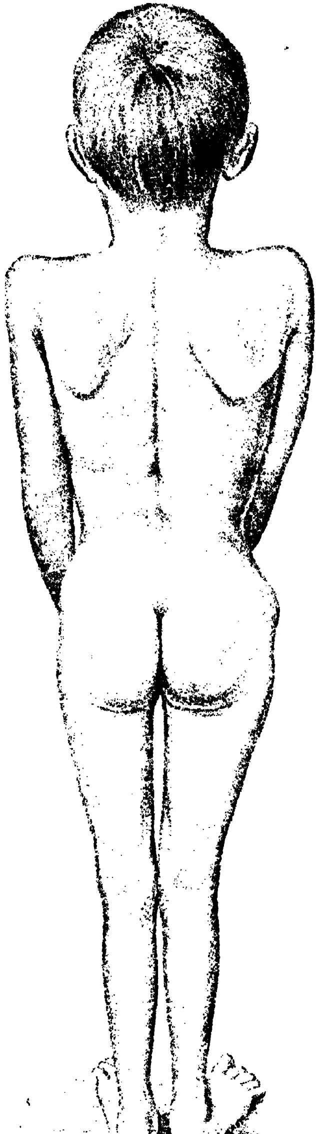


FIG. 140.—A Back View of a case of Bilateral Congenital Dislocation of the Hip. The prominence of the trochanters, and the shortening and feeble development of the lower extremities are noticeable.

FIG. 141.—Side view of previous figure, showing the Lordosis.

in the acetabulum, whereas in congenital dislocation and certain other conditions the trochanter is above this line.

(2) What is the position of the head? The head of the femur can be more easily palpated when out than in the socket, and it should be felt for in the following situations:—Below the anterior superior spine, or on the dorsum ilii, and its presence in one of these positions verified by rotating the limb. An important point is the fact that in young subjects the head of the femur can be *telescoped* upward and downward by traction on the limb with the pelvis fixed. Pure anterior dislocation of the head is very rare as a primary condition. The so-called anterior are usually antero-superior displacements, and they show a great tendency to become posterior displacements.[1]

(3) As to the causation of dislocation, whether congenital or not, we must exclude paralysis, traumatism, coxitis, either tuberculous or osteomyelitic, or the dislocation sometimes seen in enteric fever, and also coxa vara. This is by no means a difficult matter as a rule, and a careful perusal of the articles dealing with the various conditions, and practical experience, will enable a diagnosis to be made. It must not, however, be overlooked that infantile paralysis[2]

anterior-superior spines; a second line through the tips of the trochanters. Normally the second line should be parallel with the first. In congenital dislocation it approaches the first on the affected side, and the distance from the anterior-superior spine is lessened.

[1] If we are dealing with a pure supracotyloid dislocation with no particular anteversion or incurvation of the neck, hyper-extension and rotation outward of the limb turns the head forward, and it is felt under the sartorius or anterior superior spine; while flexion and rotation in will turn the head back into the iliac fossa, and it is felt in the buttock. The ascertained position of the head, and its relation to the shaft, as gauged by the transverse axis of the condyles and outer surface of the great trochanter, will give some information as to the shape of the neck and the presence of anteversion.

[2] Dislocation has been seen in children, the subjects of Little's disease. It may be a mere coincidence, or the dislocation is consecutive. This point has a bearing on the question already discussed. Is every so-called congenital dislocation purely congenital? Wollenberg records four cases of dislocation of the hip in Little's disease (*Zeitschr. f. orth. Chir.* Bd. xv. p. 118, 1904); Karl Gangele adds four more (*ibid.* 1906, pp. 332-361); Mr. Jackson Clarke, in the discussion on Mr. Openshaw's paper at the Clinical Society, mentioned another (*Lancet*, 17th January 1903). Reviewing the literature, we ought to consider certain aspects of the causation of so-called congenital dislocation. We have (1) Congenital dislocation proper. (2) Conditions of fœtal origin, with the actual displacement taking place during infancy. (3) A condition very much like this, but put down by Fröhlich (*Rev. d'orth.*, January 1906), Drehmann (*Fünfte deut. Kongress f. orth. Chir.*, 1906), and others, to certain vague and hypothetical conditions such as "dry" arthritis. (4) Is it possible that dislocation may take place at the outset of a coxalgia? References on this point are Broca, "Luxation brusque au début d'une coxalgia," *Rev. d'orth.*, September 1906; Kirmisson, "Sudden Luxations in the Course of Coxalgia," January

or coxalgia may supervene in a subject affected with congenital dislocation, but it is of course rare.

The condition most difficult to distinguish from congenital dislocation is coxa vara. In both, the trochanter is above Nélaton's line, in both a limp is present. In coxa vara, however, the head of the femur can be felt in its normal position, and there is no telescoping. The difficulty can be at once cleared up by the aid of a good skiagram.

Prognosis.—Without treatment the outlook is bad. According to Lorenz and Max Reiner, a spontaneous cure is practically impossible. They make, however, a guarded exception in certain cases of posterior subluxation in infants, described by Lange. Luxation of the hips in the flexed position of the lower limbs *in utero* is transformed by extension of the limbs in the act of birth into a subluxation. Certain other observers have recorded what they believe to be cases of spontaneous cure in older children.[1] These cases appear to have been merely subluxations. But even if such statements are accepted, spontaneous cure is so rare as not to influence in any way the necessity for treatment.

Generally speaking, the deformity, lameness, and shortening increase rapidly during the years of growth. The femoral head recedes farther and farther from the acetabulum, until arrested by the tension of the thickened capsule and the stretched muscles. Actual ne-arthrosis is a very rare occurrence, but sometimes a certain amount of resistance to the farther progress upwards of the head is presented by inflammatory thickening around the capsule.

In bilateral cases the progress of the deformity is more rapid, and as age advances and weight increases, the irritation from fatigue gives rise to attacks of painful spasm and rigidity of the muscles, a point to be remembered in diagnosis. In later life, the pain and disability, particularly in obese patients, become so great as to lead to practical invalidism.[2]

1899; *Bull. de l'Acad. de méd.*, 13th March 1900; Jouon, *Rev. d'orth.*, January 1901, and Thèse de doct. de Paris, 1901.

Drehmann also at the last two German Congresses of Orthopaedic Surgeons drew attention to those cases of dislocation of the hips following acute inflammation of the joint in sucklings, where the clinical symptoms could not be distinguished from congenital dislocation.—*Zeitschr. f. orth. Chir.* xiv. p. 712 *et seq.*

[1] Fröhlich, *Rev. d'orth.*, January 1907; also July 1907, pp. 404-406. Cases are related by Nové-Josserand and Kirmisson, *ibid.*, July 1907, pp. 404-406.

[2] Ridlon (*Trans. Amer. Orth. Ass.* vol. xv. pp. 294, 295), however, relates that there was an eminent neurologist in Chicago so affected who was able to make a running jump over a table.

CHAPTER VI

CONGENITAL DISLOCATION OF THE HIP (*Continued*)

Treatment

The present status of the treatment of congenital dislocation of the hip is due chiefly to the efforts of Paci, Hoffa, and Lorenz. Until the year 1890, attempts made to remedy the displacement were nearly always futile.[1] To Hoffa all credit is due for his conception of enlarging and re-forming the acetabulum, with implantation therein of the head of the femur, after reduction had been made possible by tenotomy of all the resistant structures. This idea he carried out.

Inspired by Hoffa's work, Lorenz commenced to operate,[2] at first on the same lines, but being struck by some disadvantages in the procedure, he exhaustively reinvestigated the whole matter. Subsequently Lorenz so modified Hoffa's procedure that his method may fairly be claimed as a new operation. It is therefore generally spoken of as the Hoffa-Lorenz open method.

About the same time Paci was experimenting with a purely manipulative method. Lorenz, who at first was sceptical, became convinced of its possibilities, and he modified it in accordance with his own researches. Thus the "bloodless," which is much better called the "manipulative" method, was developed. It has gradually forced treatment by open operation into the background, and now holds the field.

We must, however, go at some length into the various methods for the following reasons:—The manipulative method is by no means applicable to all cases, and in fact is successful in less than 60 per cent of cases where it has been tried. The question arises, What

[1] We must, however, not omit to mention the work of Buckminster-Brown, Adams, and Pravaz. A very few cases recovered by continuous extension.

[2] Lorenz performed Hoffa's operation for the first time on March 3, 1892, *Pathology and Treatment of Congenital Dislocation of the Hip, based on a Hundred Operative Cases*, Vienna, 1895.

can be done for the remainder? Are we to be content with palliative measures, or to leave them alone? The natural inclination is to ask, Is it not possible to carry out some other procedure? In some cases this is so.

It is quite clear, therefore, that the various operative measures will need discussion. Again, many cases come before surgeons more familiar with ordinary surgical procedures than with manipulative measures, and if familiarity breeds contempt, the want of it is certainly often associated with scepticism. The natural bias then of the general surgeon will be towards the open operation. Therefore it must be discussed.

The advances in the treatment of this deformity are of recent growth. In order to arrive at a good understanding of the subject we must deal with them in chronological order. The earlier methods are naturally less valuable, and are likely to fall into oblivion. At the same time, if we grasp the reasons of failure, we pave the way to success eventually.

We will therefore refer in the first place to some early attempts to obtain a ne-arthrosis in the best possible position outside the acetabulum. Jules Guérin was the first who tried to procure a ne-arthrosis by destroying the capsule, and placing the head in direct contact with the ilium. Margary[1] excavated a new acetabulum behind its usual position. The patient, aged fifteen years, died of sepsis, and Margary did not renew his attempt. Ogston formed an acetabulum above the normal position.[2] Israel attempted to nail the head against the iliac bone. Other surgeons have tried to obtain a *point d'appui* for the head, that is, to create an obstacle to its upward displacement. Thus König[3] detached a periosteal flap from the trochanter and neck of the femur, turned it upwards, placed the head of the femur in contact with the ilium, and stitched the flap firmly to the capsule.[4] Lannelongue[5] injected chloride of zinc solution so as to induce an outgrowth of bone above the femoral head. Kirmisson[6] drove ivory pegs, and Witzel[7] gilded nails, into the iliac bone above the head. Both surgeons found the results unsatisfactory. The present writer has operated in the following way, with satisfactory results in one case out of four:—

1 *Arch. di ort.*, 1884, p. 381.

2 *B.M.J.*, 1885, vol. ii. p. 1116; and 1886, vol. i. p. 500.

3 *Centralbl. f. Chir.*, 1891, S. 146.

4 The patient died of diphtheria four months afterwards, and an osseous crest had developed on the side of the pelvis above the head of the femur. Karynski, Karewski, and Gussenbauer record good results, and Lorenz a relapse. Hoffa said it was too severe a proceeding.

5 *Bull. de la Soc. de chir.*, 1891, p. 770.

6 *Rev. d'orth.*, May 1906, p. 265.

7 *Centralbl. f. Chir.*, 1901, No. 40.

A hole was drilled through the head of the femur, and three strands of very stout silkworm gut were passed through it. Then by means of a specially curved needle the silkworm gut was carried through the periosteum of the iliac bone at a spot as near as possible to the normal acetabulum and the ends firmly tied. In this way the head of the femur was sutured to the iliac bone as closely as possible, and in such a direction as to permit the largest amount of flexion. No further telescoping of the head occurred during five years, and flexion to a right angle was possible.

Apart from the fact that only occasional and modified successes have been demonstrated in these cases, and by modified successes we mean the confining of the head to the position selected, such procedures have certain inherent drawbacks. The shortening is not overcome, the ilio-trochanteric muscles still act at a disadvantage, and the Trendelenburg symptom persists. Further, ankylosis is likely to result,[1] even with prolonged and careful after-treatment.

Hoffa's Operation.—His aim was to obtain reduction by division of all the structures preventing the elongation of the limb. He opened the capsule, excavated the acetabulum, and tried to implant the femoral head in it.

The thigh was flexed, and the tense hamstrings were divided subcutaneously near the tuber ischii. The limb was then extended and abducted, and the adductors tenotomised subcutaneously. By the open method the tensor vaginæ femoris, the sartorius, and the rectus femoris were severed.[2] Hoffa next detached all the muscles inserted into the greater and less trochanters by the subperiosteal method. The capsule of the joint was now opened, and the head of the femur turned out of the wound. He then proceeded to deepen the acetabulum by a specially devised curette.

In Hoffa's hands the mortality was considerable, three deaths in fifty-four cases being directly due to the operation, and several cases became septic. Lorenz recorded a case of secondary hæmorrhage, followed by sepsis and a state of lameness worse than ever. Hoffa

[1] Ankylosis in good position and with little shortening is not, in unilateral cases, to be considered an entirely bad result. It is a less disability than an unreduced and progressive congenital dislocation. However, the fact is that ankylosis and contracture usually co-exist, and the limb becomes fixed in a flexed and adducted position. Such a result is to be deplored. Double ankylosis is a terrible result, and therefore open operations on both hips should never be performed at one sitting.

[2] The great influence of a hypertrophied tensor vaginæ femoris in producing inversion of the limb can only be appreciated by those who have been compelled to divide it when it has been the subject of severe contracture in spastic paraplegia, as the author observed in two cases.

found that the risk of reluxation was very considerable,[1] and even when the head of the femur remained in the acetabulum the functional result was not good on account of the extensive division of the muscles. Happily the operation has never been extensively practised, and in some surgeons' hands, other than Hoffa's, some of the results have been very distressing.

Lorenz's Open Method.[2]—He recognised that it is not essential to divide the trochanteric muscles, and further approached the capsule by an incision from the antero-external aspect of the joint. As Lorenz developed his ideas, the leading fact became the conservation of all the muscles, save in some cases tenotomy of the adductors.

The steps are as follows:—(1) If much shortening is present, weight extension is applied for a week or so. (2) At the actual operation the head is brought down by manual or instrumental traction, and perhaps tenotomy of the adductors is added. (3) An incision is made from near the anterior superior spine downwards and outwards to the great trochanter, and by this means the capsule is laid bare. (4) It is opened by a T-shaped incision, the acetabulum deepened, and the femoral head, if necessary, reshaped and replaced in the acetabulum.

Lorenz's first results at Albert's clinic were disastrous. In twelve cases two deaths occurred from septicaemia, and three others suppurated. One became ankylosed on both sides. But in a subsequent series of a hundred cases he says that no deaths occurred, and only one case failed to unite by first intention.[3] However, Lorenz abandoned this method because reluxation was found to be fairly frequent, and very prolonged treatment was necessary to ensure mobility of the joint and prevent contracture.

In certain cases there is no doubt, where reposition cannot be effected by the manipulative method, and where the difficulty of doing so presumably is due to deformity of the head of the femur or to the condition of the capsule, the open method is still of value. Such conditions, however, are not often met with in infants, and in

[1] This is the author's experience gained from ten cases: reluxation occurred in six, but four of the ten cases have proved after six years to be perfect functional and anatomical successes.

[2] *Centralbl. f. Chir.*, 1892, No. 31.

[3] In ten of the author's cases operated on by the open method one suppurated. She contracted scarlet fever from a neighbouring patient; however, she recovered, and the reposition was perfect, and still quite stable after twelve years. If we could after, or at these operations introduce a controllable or mild degree of sepsis, sufficient to stimulate bony outgrowth from the acetabulum, but not such as to cause ankylosis, then the whole problem might be solved.

future, earlier intervention by the manipulative plan will gradually relegate the Hoffa-Lorenz operation to obscurity; because, while the number of immediate successes in the latter case, so far as reposition is concerned, is large, yet the ultimate functional result is disappointing,[1] unless prolonged and careful after-treatment, extending over at least two years, is carried out.[2] The age-limit for the open operation is lower than that for the manipulative; and if the former is done too late, ankylosis may follow.

Jackson Clarke's Open Operation.—Mr. Clarke says (*Congenital Dislocation of the Hip-Joint*, pp. 69 *et seq.*, London, 1910): "In some cases, shortly after removal of the plaster retention apparatus, when it is found that the head of the bone is becoming redislocated, a second period of retention with increased hyper-extension, and with the knee elevated somewhat towards the axilla, should be tried. If this has been done without success, or if there is no trace of a raised border to be felt on moving the head of the bone in and out of the acetabulum, I think it is a waste of time to proceed on bloodless lines . . . and I have designed and carried out the following plan, first described in the *Lancet* April 1909:—

"An incision is made in the outer two-thirds or more of a line from the posterior superior iliac spine to the top of the great trochanter. The skin and fascia being divided, the gluteus maximus is seen with its fibres lying parallel to the incision; it is divided, and the two portions are held apart by retractors. What is seen at this stage differs from the normal anatomy, and it varies in different cases."

In the first case operated on by Mr. Jackson Clarke, "the whole of the capsule lay immediately beneath the gluteus maximus, the pyriformis not being seen. . . . I opened the capsule at the lowest part of its posterior surface, the incision being only large enough to admit a periosteal elevator, Farabeuf's curved rugine; by means of this the periosteum and the cotyloid ligament were detached for about half an inch at the upper and posterior borders of the acetabulum.

[1] In ten open operations, performed on this plan by the present writer, six relapsed. In the four which were successful the success was permanent. It should be added that the open operation was never done until the manipulative method had been tried and failed.

[2] These views are not held by all surgeons. H. M. Sherman (*A.J.O.S.*, Jan. 1905) is a determined opponent of the manipulative method, and favours open operation. His results, however, are not particularly encouraging. Eight subluxated or reluxated at once, and in some of the seventeen stable cases the stability was only of two months' duration. Those who have experience of the operation recognise the fact that motion, which is comparatively free and painless at first, usually becomes restricted later.

Next three stout silk stitches were passed in turn through the periosteum thus raised into the joint-cavity under the cotyloid ligament, out of the capsule again and through a fold of the capsule, then once more through the capsule near its femoral attachment where the two ends were tied. These stitches removed the over-distension of the back of the capsule, and held the cotyloid ligament over the outer part of the head of the femur. The limb was put up in plaster as after the manipulative operation which must always have preceded this open operation. . . . I hope that this simple operation will prove capable of giving a strong and useful joint in every case where the manipulative operation has been thoroughly tried and has failed."

E. H. Bradford (*Amer. Journ. Orth. Surg.* vol. vii. p. 57 *et seq.*) describes a proceeding even more simple. It consists of incising the capsule, dilating or cutting the constricted portion or neck of the capsule, replacing the head and stitching the capsular flaps "in such a manner as to form, when cicatrisation has taken place, a new cotyloid ligament holding the head in place."

The *Open Method* is called for when repeated attempts at reduction have been tried and failed, and when, after reduction has been accomplished, and the limb has been brought down from the abducted and hyper-extended position, the head becomes re-dislocated.

In order to illustrate the fact that the manipulative method does not suffice for all cases, I quote the case of a girl aged seven years, who came under my care at Westminster Hospital. No fewer than eight attempts were made to reduce the dislocation by manipulation, and all were unsuccessful. By way of preliminary treatment, exsection of portions of the adductors, and weight-extension up to 10 lbs. for several weeks, were carried out. Traction by pulleys up to what was considered the "danger-point," and repeated forcible pulling on the limb, were tried. Even when the great trochanter had been drawn down to one inch below its normal position, flexion, abduction, hyper-extension, circumduction inwards and outwards, all failed. It was therefore decided to operate by the open method. Two stages of the operation are represented by the excellent drawings (Figs. 142, 143) of my friend and colleague, Mr. E. Rock Carling. Briefly, the difficulties were (1) the head of the femur, dislocated outwards and backwards, was anteverted to a full right angle, so that it looked directly forwards (Fig. 142 A), and coxa vara was present to an extreme degree. (2) The ilio-psoas tendon

(Fig. 142 C) passed across the middle of the capsule, between the caput femoris and the margin of the acetabulum, and formed a constriction of the capsule, into an hour-glass shape (Fig. 142 AB). On account of the tightness of the ilio-psoas tendon and its close proximity to the neighbouring parts, its division was not easy nor ly free from risk.

FIG. 142.—A drawing by Mr. E. Rock Carling to illustrate the condition of the parts during an "open" operation by the author for the Reduction of an Intractable Congenital Dislocation of the Hip.

A, The dislocated and anteverted head of the femur covered by a portion of the capsule. B. The inner portion of the capsule adjacent to the acetabulum. Between A and B the capsule is constricted by the ilio-psoas tendon, C, which has become a suspensory ligament. C, The ilio-psoas tendon. D, The rectus femoris muscle.

(3) On opening the capsule, after section of the ilio-psoas tendon, the ligamentum teres was seen to be much thickened and adherent to the posterior wall of the capsule. (4) A diaphragm existed across the junction of the inner and outer halves of the capsule, and in it was a small buttonhole (Fig. 143 E) half an inch broad and one-third of an inch from above downwards, through which it was evident that the head of the femur never could pass. When the capsule had been freely opened, reduction of the head of the femur was easily accomplished. The parts were sewn up, and the limb put up in plaster in abduction, hyper-extension and rotation inwards. The plaster was subsequently changed, the limb brought down to an angle of 45° with the transverse axis of the pelvis, the foot still pointing inwards, and the child was allowed to walk. It remains to be seen whether the dislocation will remain reduced when the limb is freed from all restraint. If not, section of the femur below the trochanter, followed by rotation outward of the limb below through 90°, should be done.

Manipulative Method.—This is the outcome of much careful

thought. The manipulations of Paci, which are very similar to the manipulative reduction of traumatic dislocation, have shown that reposition, or something very like it, is possible. But what Paci gained by his first three manœuvres he jeopardised by the fourth, when he brought the affected limb parallel to the median line.

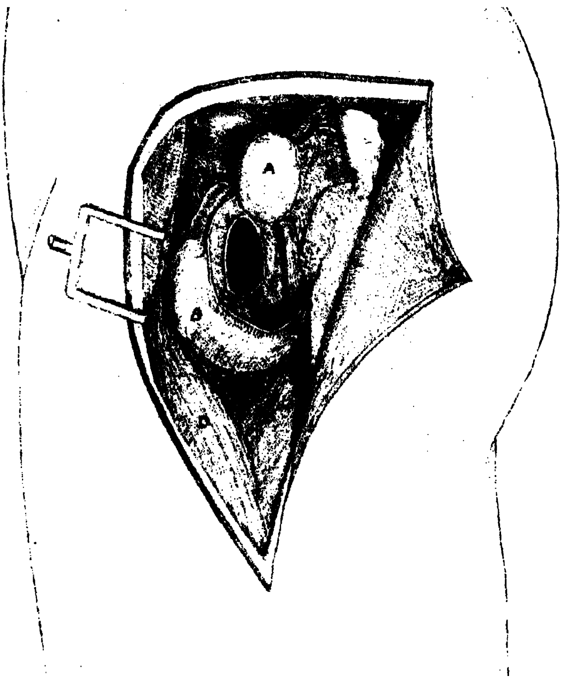


FIG. 143.—A drawing by Mr. E. Rock Carling of a further stage of the operation. The capsule has been opened, the anteverted head of the femur exposed, and the ilio-psoas tendon divided. A, The anteverted head of the femur. B, The inner portion of the capsule. C, The cut ilio-psoas tendon. D, Rectus femoris muscle. E, The buttonhole aperture in the diaphragm forming the outer wall of the inner part of the capsule.

By a consideration of the accompanying figure it is easy to see why this is so (Fig. 144). AB represents the side of the pelvis, CD the femur held in position by the muscles AD, BD. Now, the acetabulum apart (for our present purpose it may be considered as non-existent), the taut muscles (AD′, BD′) will hold the rectangularly abducted femur (D′C) more securely in contact with the pelvis than when it is in the position DC, or approaching the long axis of the body. In many respects the diagram is far-fetched, but it is clear that the more nearly CD′ approaches CD, the greater is the tendency to displace C towards A.

To attain stability, then, with a deficient acetabulum the limb must be

abducted to about 90° with the side of the pelvis. The value of abduction had been noticed and utilised apart from the manipulative method, but it was left to Lorenz to combine the manipulative reduction of Paci with the stability afforded by the abducted position. Further, the researches of Lorenz, and his experiences with the open operation, showed that a much more thorough and radical procedure than that of Paci was necessary to secure true reduction. The diagram also illustrates the necessity of sparing the muscles, as on these not only the cure, but to a large extent the subsequent functional use of the limb, depend. For the combined tension of all the muscles keeps the head forced into the acetabulum, and steadies it there.

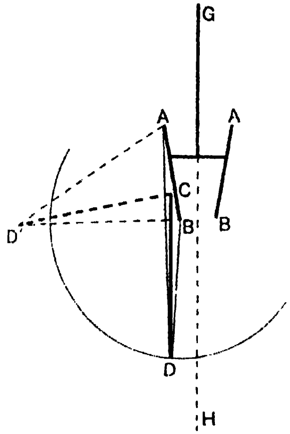


Fig. 144.—Schema to explain the greater stability of the Reduced Hip when the femur is abducted, than when it is lying by the side of its fellow. For explanation see text (V. Moxey).

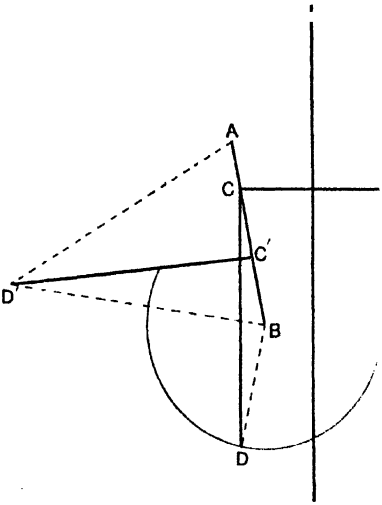


Fig. 145.—Schema to explain the necessity of lengthening the Adductors before attempting to reduce a Congenital Dislocation. For lettering see text (V. Moxey).

The Manipulative method is a "complex" of many considerations, and is the result of most careful trial. Its principles must be grasped and applied to each individual case, for it is not possible to use it by the rule of thumb method only. The steps of the actual method are as follows:—

The patient is anæsthetised. The adductors are divided subcutaneously, the dislocation is reduced, and the limb is fixed in abduction in a plaster of Paris spica. The first fixation position is temporary only, and is followed by longer fixation in a less strained position. The various steps we will now deal with at sufficient length:—

(*a*) *Lengthening of the Adductors.*—A glance at Fig. 144 shows the necessity of this procedure, BD′ being obviously longer

than BD. But in reality the case is still more urgent. Thus, in Fig. 145 CD is the dislocated femur, C′D′ is the reduced, and the difference between BD and BD′ is more marked than ever. The diagram is, of course, intentionally exaggerated, but in reality the difference may be very great. The difference is indeed so great that Lorenz has in the case of the adductors to depart from his principle of maintaining the integrity of the muscles. Even if simple stretching permitted reduction, the tension would be so great that relaxation must follow. Lorenz deals with these muscles, not by tenotomy, but by manipulative rupture or myorrhexis through the unbroken skin. The author, however, prefers as a rule to perform preliminary tenotomies by the open method fourteen days before the reduction is attempted.

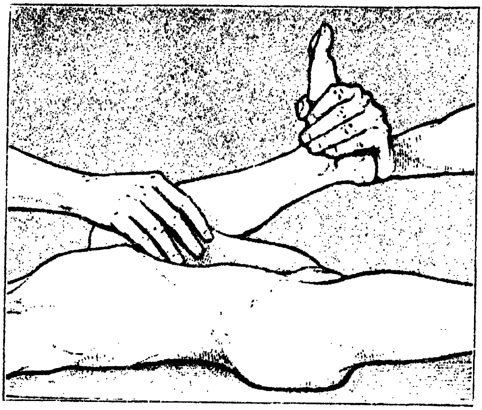


FIG. 146.—Fixation of the pelvis, the assistant flexing the sound limb on the abdomen (*Medical Annual*, 1903, after Brün).

A word as to myorrhexis:—The patient, anaesthetised and lying in the supine position, is brought to the edge of the table, and the pelvis is fixed by an assistant[1] (Fig. 146). A second assistant grasps the limb to be operated upon by the knee and ankle, abducts, hyper-extends it slightly, and at the same time exerts traction.[2]

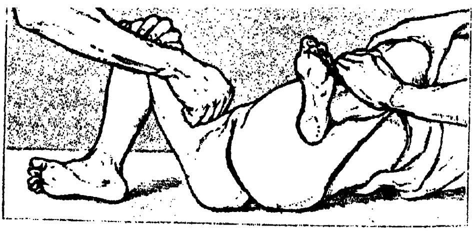


FIG. 147.—Myorrhexis of the Adductor Muscles (*Medical Annual*, 1903, after Brün).

[1] A good way to do this is by fully flexing the opposite thigh, and pressing it firmly downward. Cf. Fig. 146.

[2] It is a safe rule, in order to obviate the risk of fracture, to keep up traction in the long axis of the limb during all forcible movements.

The adductors now stand prominently out, and the surgeon forcibly massages them, pressing on the tense strands with his knuckles or thumbs (Fig. 147), or drags them down by hacking movements with the ulnar border of his hand. They give way gradually. The author prefers, as he has stated above, the more surgical measures of tenotomy, and attains the required end by excising a full inch of the adductors.

(*b*) Full abduction having been rendered possible, the next step is to stretch the muscles running parallel with the long axis of the limb, on both its flexor and extensor aspects, by either manual or instrumental traction. If the trochanter can be brought down to Nélaton's line well and good, for time is saved; but if not, the rectus is stretched by hyper-extending the thigh and flexing the knee, and the sartorius is lengthened by hyper-extending the thigh, with the knee extended, and by these manœuvres, too, the ilio-psoas and tensor fasciæ are elongated. In dealing with the hamstrings, the thigh is flexed, and the leg, which will be then found to be more or less firmly flexed on the thigh, is gradually straightened by rhythmic movements. Another way to stretch the hamstrings is to flex the fully extended lower limb at the hip until the patient's toes are nearly in contact with the shoulder.[1]

Mechanical traction by pulleys is maintained at the end of or in the intervals between these manipulations, counter-traction being made by a well-padded perineal strap attached to a hook in the wall behind the patient's head. Manual traction is, however, said to be better and safer than mechanical, but the author's recent experience has led him to revert to pulleys.[2] Much of the exertion involved in the above manœuvres may be avoided by preliminary tenotomies of the adductors and weight extension of the limb for two or three weeks beforehand. The author prefers 8 lbs or less, although on the Continent much larger weights are used.

Some American authors have advised tenotomy of the hamstrings, but the cardinal principle is to avoid, as far as possible, division of those muscles in which retention of normal function is of value to

[1] In carrying out this more vigorous manœuvre the risk of stretching and paralysing the great sciatic nerve must not be forgotten.

[2] The point about pulley-traction is that not too much is to be attempted at one sitting. If it is found that excessive traction is likely to be required to pull the head completely down, then it is better to proceed by stages, leaving intervals of three or four days. Gradually the trochanter can be brought down below Nélaton's line. Until this is effected manipulations are useless and dangerous. Care must also be taken to see that the adductors and inner hamstrings are quite slack.

the limb after reduction has taken place. Further, some of Lorenz's most troublesome cases of paralysis were associated with stretching of the hamstrings, and the effects of prolonged stretching and tension on the sciatic nerve.

(*c*) *Reduction.*—We have now arrived at this stage, namely, that the limb can be brought down approximately to the normal level; it can be freely abducted, and movement in all directions is unrestricted. We now proceed to attempt to replace the head of the bone in the acetabulum.[1] From a mechanical point of view the movements of the normal femur are those of a one-armed lever, the head of the bone not changing its position, but acting as the fulcrum or pivot about which movement takes place. In congenital dislocation, however, the femur acts as a two-armed lever, the excursions

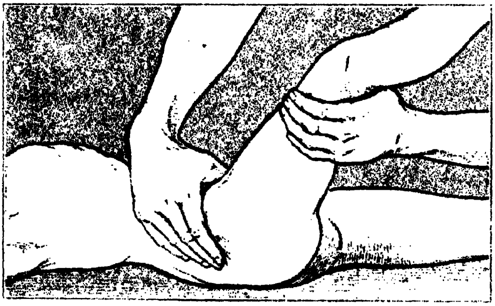


Fig. 148.—Reduction of a posterior congenital dislocation of the hip by traction on the limb and pressure behind the great trochanter (*Medical Annual*, 1903, after Bruin). The thigh is flexed and abducted, but not sufficiently in the illustration. These movements should be carried to their full extent.

of the knee-end in one direction causing a movement of the head-end in the opposite one. It follows, then, that by appropriate movements of the thigh the femoral head can be placed in any desired position with regard to the acetabulum. Thus, if the thigh is flexed to 90° the head is brought behind the posterior margin. Then by combined traction in the direction of the long axis of the limb, and pressure on the trochanter (Fig. 148), the head may be forced over the rim and into the socket. If success is not attained by traction and pressure, leverage movements may be resorted to, the shaft of the femur or the long arm being used to lever the head into place. By varying the position of the head of the femur,

[1] It is absolutely useless to attempt the actual reduction until the trochanter has been brought to or below its normal level. If it cannot be safely effected at one sitting, two or three will be necessary.

reduction can be attempted, either over the upper, posterior, or the lower wall of the acetabulum (Fig. 149).

Now certain movements are more often followed by success than others, and some are more dangerous. The levering movements over a wedge are likely to be followed by fracture. Too much time should not be expended on any one method. A fair trial having been made in one direction, we should proceed to try some other plan, since reduction is often quite unexpectedly attained on trying a fresh manœuvre, and one operator gets better results in one way, and another in a different way.

We will take the various manipulations in order, commencing

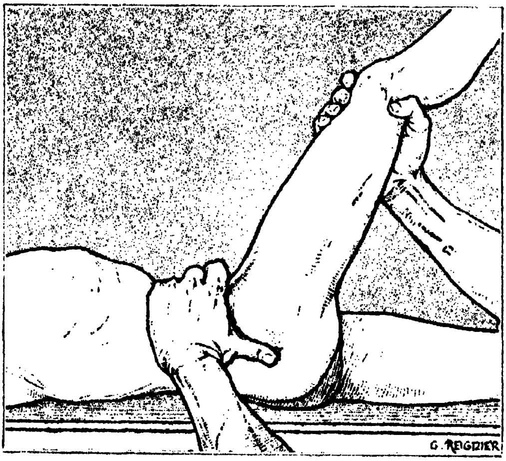


FIG. 149.—Reduction over the Posterior Edge of the Acetabulum (*Medical Annual*, 1903).

with those most likely to be successful, and most free from risk. Reduction may be attempted:—

A. By combined traction and pressure, leverage movements being avoided.

1. The head of the femur passes over the posterior wall of the acetabulum.
2. Over the lower wall.
3. Over the upper wall.

B. By means of traction and leverage movements.

1. Over the posterior wall of the acetabulum.
2. Over the lower wall.

A. By Combined Traction and Pressure, without Leverage

1. Reduction over the Posterior Wall of the Acetabulum, and Combined Traction and Pressure.—This is a good manœuvre in dealing with young children, provided the parts have been sufficiently stretched beforehand in the manner described. Kirmisson[1] appears to adopt this method to the exclusion of others. It is very useful and free from risk. In order to relax the muscles and bring the head into the desired position, the thigh is flexed to 90°, and the leg acutely bent on the thigh. Grasping the knee with one hand, the operator pulls and lifts the thigh in the direction of its long axis, abducting at the same time; while the other hand placed on the trochanter presses the head into place (see Figs. 150 and 151). The degree of rotation is varied, now well out and now well in, and flexion is increased or diminished somewhat, keeping up traction all the time with the object of lifting the anterior wall of the capsule away from the acetabulum. If the head is successfully reduced the signs are as a rule quite definite. To avoid repetition we give them once and for all.

Fig. 150.—Reduction over the Posterior Wall of the Acetabulum. The thigh is being flexed and abducted (Lorenz and Reiner).

Fig. 151. Reduction of the Dislocated Head over the Posterior Wall of the Acetabulum by hyper-extension of the flexed and abducted limb, and forward pressure of the surgeon's fingers on the dislocated head (Lorenz and Reiner).

Signs of Reduction.—The slipping of the head into place is usually accompanied by a distinct sound and a palpable shock. It is most marked when the head slips over the prominent and abrupt postero-superior margin; when the capsule does not intervene; when the ligamentum teres

[1] *Rev. d'orth.* pp. 271-273. This surgeon carries out forcible movements of flexion of the thigh on the abdomen, so as to place the head below and behind the cotyloid cavity, after performing myorrhexis of the abductors.

is not hypertrophied; and when there is very little fat in the cotyloid cavity. It is less marked when the head passes over the less prominent inferior margin, or if the acetabulum is partially occupied by soft tissue.

The shock of reduction may be not only quite distinctly felt by the operator and his assistants, but it is also appreciated by the spectators. If it is not clear at first, it can be satisfactorily elicited by reluxating and again reducing. The manœuvre may be repeated until the head is felt to slip in with a definite jerk.[1]

When the head has slipped in, a marked change is at once apparent in the limb. It is not necessary to repeat at this stage the description of the limb before reduction, as that is found fully detailed in the symptoms. Yet it should be referred to and contrasted with the following remarks.

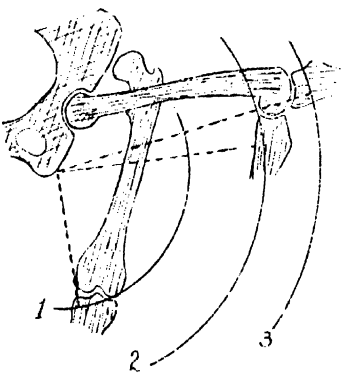


FIG. 152.—A diagram showing by the radii of the Circles—at 1, the length of the hamstring muscles before operation; at 2, the length of the same immediately after operation; and at 3, the length when the power of extending the knee has been regained by regular exercises (Jackson Clarke).

The reduced limb is lengthened, and the alteration in its shape, contour, and the relationship of the parts, are obvious. The lengthening puts the muscles on the stretch, so that the limb is held in a definite position, which is usually one of moderate abduction, outward rotation, and slight flexion. It is no longer flail-like, but meets any attempt to displace it with a springy resistance. It is, in fact, "stayed in position" like a tent pole by the tension of its guy-ropes. The strain on the hamstrings is evidenced by the knee assuming a flexed position, and resisting attempts at straightening (Fig. 152). The femoral head can be palpated under the femoral artery in the groin. As a rule, the *caput femoris* is more prominent than normal, since the acetabulum is deficient in depth. Sometimes the soft parts in the groin are pushed slightly forwards by the reduced head.

Reproduction of the dislocation affords important confirmatory

[1] Lorenz has pointed out that the click may be intensified by easing off the anæsthetic, and allowing the muscles to recover partially their tone, whilst reduction is being achieved.

PLATE XIII.

To illustrate the Manœuvres in Reducing a Posterior or Postero-Superior Congenital Dislocation of the Hip (after Calot).

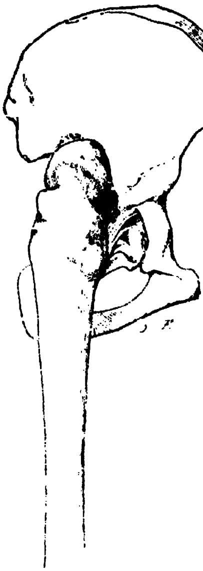


FIG. 1.

The caput femoris displaced posteriorly and superiorly. Its position before commencing the manœuvres.

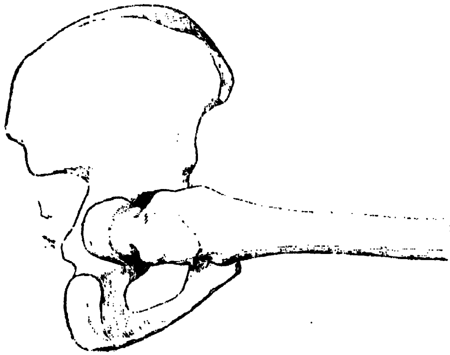


FIG. 3.

The position of the head of the femur, when the femur has been flexed to a right angle.

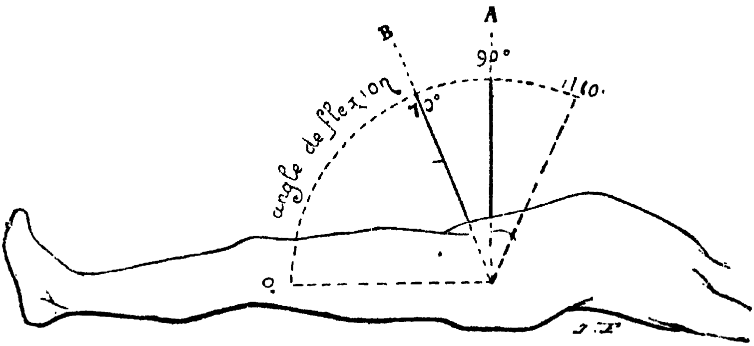


FIG. 2.

The Angles of Flexion of the Femur.

evidence of the success of the method. There should be no hesitation about reluxating the joint, since after one successful reposition a second reduction can be effected with remarkable ease. To reproduce the luxation slight pressure is exerted on the outer side of the knee-joint, so as to diminish the abduction. At a certain point, a point to be accurately noted, the head slips out with a jerk, the limb sinks down, the trochanter rises to its old position, the deformity and all the signs of dislocation re-appear, and the knee can be fully extended once more.

It has been suggested that by grasping the thigh, and boring out as it were the acetabulum, that cavity is to a certain extent re-formed. This, in the author's opinion, is a very far-fetched idea. Still, the jamming of the head into the acetabulum, the infliction of a certain amount of traumatism on any soft structures intervening between the bones, must be followed by some local reaction, which may be an antecedent to rapid structural change in the acetabulum.

Repeated reductions until the head slips in quite easily on the one hand, and on the other hand is less readily dislodged, serve to stretch the anterior wall of the capsule, which is a point of special importance in connection with retention.[1] In a dislocated limb the capsule has become adapted to a position of slight flexion and adduction. It has now to be stretched by manipulation, so that a position of abduction, extension, and rotation out of the reduced limb, is possible.

2. **Reduction over the Lower Wall of the Acetabulum by Combined Traction and Pressure.**—When the thigh is flexed and adducted, the femoral head is found below and behind the acetabulum, and further traction in the long axis of the thigh in this position may bring the head into place. These movements form the bases of other manœuvres in reduction. One advantage of this plan is that the anterior portion of the capsule is relaxed.

Schanz flexes and adducts the thigh so that its long axis crosses the umbilicus, and pulls in that direction, while pressure is made against the trochanter. Calot flexes less and adducts more, and at the same time rotates the limb well in. In order to do this

[1] It has been shown in discussing the pathology of the affection that the capsule is stretched and elongated, and forms a suspensory ligament. As this is so, where or whence arises the necessity of stretching? The answer to this question is that an elastic body, if elongated in one direction, becomes narrow and contracted in a second direction at right angles to the first. The anterior wall of the capsule is, in congenital dislocation, elongated in a direction from below and internally to above and externally At right angles to this direction the capsule is contracted.

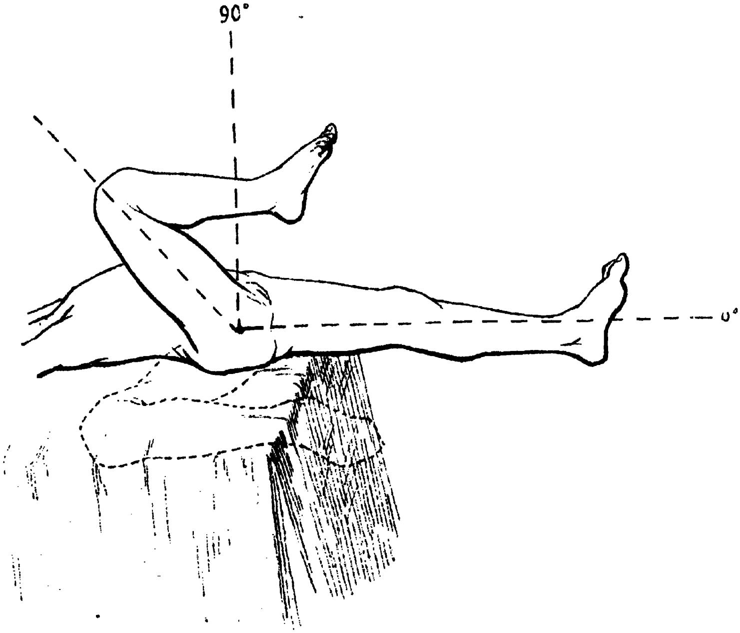


FIG. 1.

Flexion of the Thigh to its Fullest Extent (after Calot). The dotted outline of the right limb indicates the position into which the limb will eventually be placed, as most favourable for reduction.

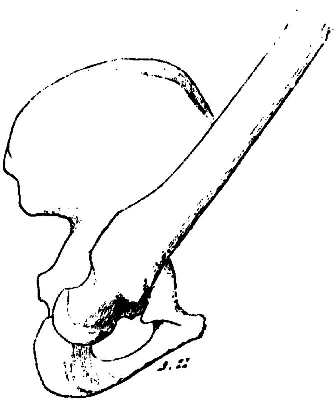


FIG. 2.

Diagram of the position of the caput femoris, when the thigh is fully flexed upon the abdomen.

the patient is placed on her opposite side at the edge of the table, with the limb about to be operated upon uppermost. The adducted thigh then points downwards over the edge of the table, and is pulled in that direction by the assistant, whilst the surgeon manipulates the trochanteric region and presses the head into place. Hoeftmann, in cases of marked anteversion of the neck, begins with adduction, following it by full flexion and marked rotation outwards.

3. **Reduction over the Upper Wall.**—The head may slip into the cavity over its upper border during traction in the long axis of the limb. The limb is extended beside its fellow, and is rotated so that the neck lies in the frontal plane. Two assistants then pull upon it rhythmically, whilst the operator pushes the great trochanter down. If the head goes in, the limb is at once abducted under the same traction.

Lange flexes the limb to 160°, adducts it to 150°, but does not rotate it. Traction on the limb in this direction brings the head against the upper and posterior segment of the margin of the acetabulum. He then reduces it by smartly rotating inwards and abducting.

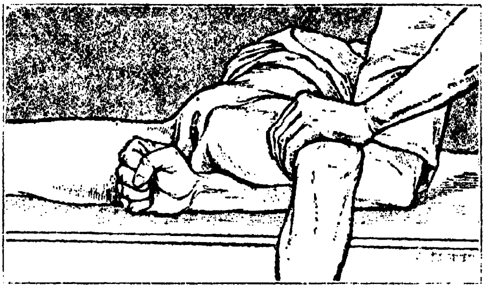


Fig. 153.—Reduction of the Dislocated Caput Femoris over the Posterior Edge of the Acetabulum by Leverage (*Medical Annual*, 1903, after Bruin).

B. Traction and Leverage Movements

1. **Reduction by Leverage Movements over the Posterior Wall of the Acetabulum.**—In this procedure, often known as Hoffa's method (Fig. 153), the surgeon places his forearm under the upper end of the femur, which has been abducted to the right angle and strongly rotated outwards. His forearm forms the fulcrum for leverage. By depressing the knee and gradually hyper-extending the limb (Fig. 153), the femoral head may be levered into place. But this is a dangerous procedure, as fracture has often occurred.

Lorenz uses a padded wooden wedge for this purpose, and this is more dangerous than Hoffa's method. Yet, on the other hand, it

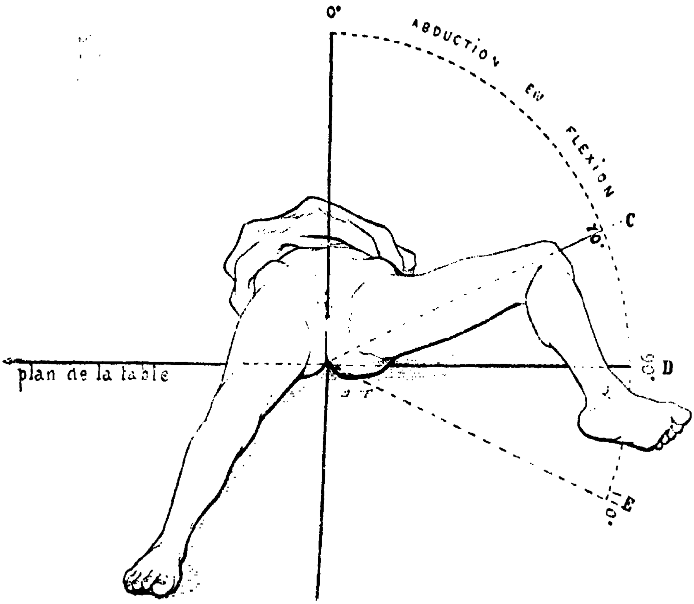


Fig. 1.

Indicating the excursion of the limb in full flexion and abduction of the thigh (after Calot). The limb may be carried behind the median plane of the body to an angle of 110°.

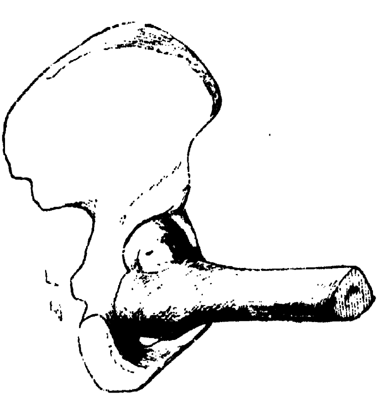


Fig. 2.

The Entrance of the Caput Femoris into the Acetabulum, when the thigh is flexed, abducted, carried behind the median plane of the body, and rotated outward (Calot).

has the advantage that both the operator's hands are free to grasp the thigh, and he can exert traction and leverage at the same time.

As the moment of reduction draws near, the outline of the head in the groin becomes more palpable.

2. **Reduction by means of Leverage Movements over the Lower Wall.**—This is a modification of Hoffa's method, just described. The fully abducted limb is rotated out, and then manipulated to and fro like a pump handle, the knee being brought on the one hand towards the patient's axilla, and on the other into hyper-extension. The femoral head is thus levered in over the lower and external margin.

The author adopts the following method in reducing a dislocation :—He advises that the patient be placed upon a low and narrow operating table, so that it is possible to stand well over the patient and obtain full control of the limb. As a preliminary measure, the adductors are divided subcutaneously in children under four years of age, and in those over that age portions of the muscles are excised. At the same time the tendons of the sartorius and tensor fasciæ femoris are cut subcutaneously just below the anterior superior spine. Extension by weights up to 8 or even 10 lbs. is then employed for fourteen days, so as to stretch the ilio-psoas tendon and the capsular ligament.

At the time of reduction the child is placed supine, and a sand-bag is laid beneath the affected hip. Traction by pulleys is now used, the limb being in extension and abducted to 30° to 45°. The traction force is very gradually increased until the top of the great trochanter is well below Nélaton's line, and if it can be brought ½ to 1 inch below this line, the easier will be the reduction. In children above four years of age it may not be possible to bring the trochanter well down at one sitting, because of the risk of injuring the sciatic and other nerves. The child is then put back to bed, the weight-extension is re-applied, and in three days further pulley-traction is made; this is usually sufficient to draw the trochanter well down. The pelvis is now fixed by one assistant, who flexes the other limb on it, and holds it firmly. The pulleys are removed from the affected limb, traction still being maintained by another assistant. The operator has naturally been careful to assure himself, by palpation, of the position of the head of the femur, of the direction of the neck, whether normal, valgoid, or varoid, and of the presence or absence of any incurvation of the neck. He now ascertains that the thigh can be moved freely in all directions, particularly abduction and hyper-extension. If it does not do so, by a series of movements in the desired directions the muscles are gradually stretched, until the requisite freedom is attained

The procedure now varies accordingly as we are dealing: *A*. With an anterior or antero-superior dislocation. *B*. With a posterior or postero-superior dislocation.

A. In anterior and antero-superior dislocation, and presuming that it

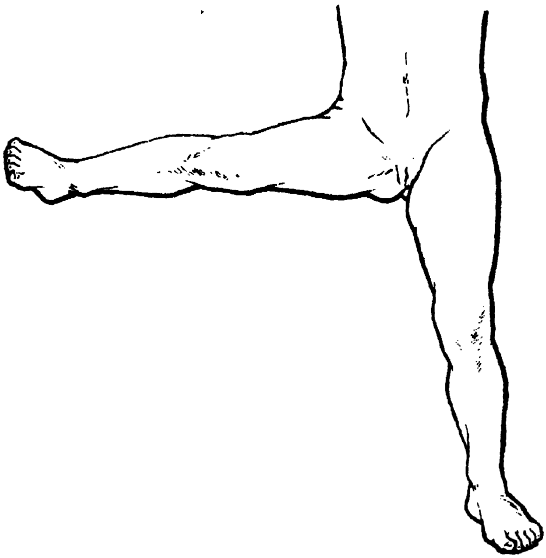


FIG. 1.

The Anatomical Position of Abduction of the Thigh; the patella looks directly forward (Calot). The abduction position of reduction differs entirely. It is a combination of full flexion of the thigh, and then full abduction and some external rotation.

FIG. 2.

Commencement of the Movement of Abduction of the Flexed Thigh, so that the patella looks directly outward. Also by digital pressure on the back of the caput femoris, an attempt is being made to lever it over the rim of the acetabulum (Calot).

is on the right side, the surgeon places the inner edge of his left hand firmly in the groin and presses against the caput femoris. With his right hand he grasps the patient's thigh, flexes it, and using it like a rod, pushes the head of the femur well down towards the acetabulum. The descent of the head is further assisted by the pressure and leverage of the surgeon's left hand in the groin. Abduction of the flexed thigh to the right angle is the next movement, followed by hyper-extension. In young children the head often slips in at this stage. If no reduction takes place, pulley-traction is again applied to the abducted limb, and vigorous movements of flexion, abduction, rotation, in and out, circumduction, and hyper-extension are made. During these manœuvres the dislocation is often reduced. If not, failure is due to some abnormality of the neck of the femur or to the defective condition of the acetabulum. When the neck of the femur is varoid and curved, so that it is concave forward, rotation and circumduction inward, with the knee pointing to the umbilicus, may prove successful. If the neck is valgoid, the knee of the fully abducted limb should be drawn upward until it points to the axilla on the same side. If the dislocation disappears in this position, the limb should be put up in the negative or axillary position, otherwise the head will slip out.

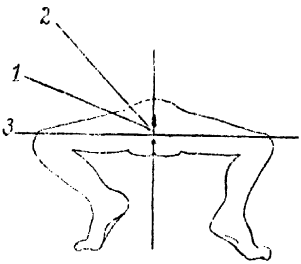


FIG. 151.—Outline of the Limbs traced from a photograph of a patient immediately after operation. Line 1 shows the degree of separation of the flexed limb that the hip-joints allow in a normal position: line 2, the degree in a case of congenital dislocation of the hip before treatment; and line 3, after Lorenz's operation. Note that the inner aspect of the knees in 3 is just behind the frontal plane, which passes through the middle of the perinæum (Jackson Clarke).

B. If the dislocation is posterior, full abduction and rotation out are to be aimed at, and some hyper-extension of the limb in these positions must be secured. As Mr. Jackson Clarke has insisted, the positions favourable to reduction are abduction and hyper-extension. The head of the femur either slips into the acetabulum, or can be levered in by the pressure of the surgeon's hand placed on the back of head of the femur. If it does not, the flexed and abducted limb is freely circumducted, hyper-extended, and rotated out.

The author has experienced much less difficulty with posterior and postero-superior displacements than with the anterior forms, particularly if coxa valga or vara, with concavity of the neck forwards or backwards, co-exists.

We will suppose that by some one or other of the methods[1]

[1] At the Boston (U.S.A.) Children's Hospital, Bartlett's apparatus is used for difficult cases, and E. H. Bradford has perfected an appliance to aid in fixing the pelvis and exerting pressure on the femoral neck and head (*Amer. Jour. Orth. Surg.* Vol. vii. No. 1, p. 62).

described above reduction has been effected. We must now pass on to discuss the question of retention. We shall subsequently consider what is to be done in cases of failure to reduce.

Retention.—The reduced limb is fixed in the Lorenz position (Fig. 154) in plaster of Paris, until the necessary local changes and adaptations of structure have taken place. Many points present themselves for consideration, and we may at once say that no rule-of-thumb procedure is likely to be effectual in all cases.

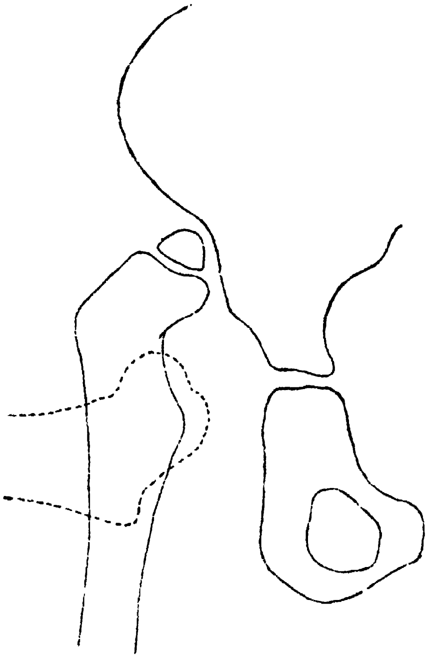


FIG. 155.—Outlines from Skiagrams. The interrupted outline shows the position of the femur after operation (Jackson Clarke).

Each case must be treated on its own merits, and only general principles can be laid down. Some of the points to be considered are the following:—

1. In what position is the limb to be fixed? It is to be fixed in that position reached by flexing the thigh to a right angle, and then abducting it through 90° (Fig. 155).

2. Is this same position to be maintained throughout the whole of the fixation period, or can it be modified advantageously as time goes on? The position is not altered throughout unless certain special indications are present.

3. How long must fixation in plaster be continued, and how often should the bandage be changed? Fixation for five to eight months, and often twelve months or longer, will be needed. The bandage will require renewal every three months, and at much shorter intervals if the nursing is indifferent.

If the reader bears constantly in mind this very brief summary, the following details will appear less confusing. Still adhering to the same order, we will first discuss:—

The Position of Fixation.—The limb is fixed in abduction

at 90° at least, that is, in ultra-physiological abduction, and possibly it may be found during the operation that even this degree has to be exceeded to ensure stability. This abducted position is not that of the anatomical text-books (Plate XVI. Fig. 1), in which it is considered as a movement in one plane only, like the opening of the blades of scissors. In anatomical abduction, the patient lying supine, the patella looks directly upwards, that is, no rotation is present. In other words, the transverse axis of the knee-joint remains in the frontal plane of the subject. If the limb, thus anatomically abducted, be rotated out through a quarter of a circle the position preferred by Lorenz would be obtained (Plate XIV. Fig. 1). The position is usually described, however, as flexion 90°, then abduction 90°, with no rotation; which is preferable, because it indicates the procedure by which the position is most often reached; if we wish to control the rotation, the knee must be enclosed in the bandage. Of this Lorenz disapproves, but the author finds it most useful, especially in young and active children. One objection to this nomenclature is that on abduction reaching 90° no flexion remains, and if the abduction goes beyond 90° hyper-extension is reached. That is, in a movement of abduction through a small arc, say from 85° to 95°, the limb passes from flexion to hyper-extension [1]—a fact, although at first sight confusing (p. 171).

We have already, on p. 171, dealt with certain aspects of the abducted position, and the Vienna school is convinced from practical experience that its advantages are very real. They affirm that any diminution of it predisposes to posterior reluxation, and they do not diminish the abduction throughout the entire fixation period, as they believe so strongly in its efficacy.

In the abducted position the head of the femur is not in the greatest possible contact with the acetabular surface, and many authors do not lightly disregard this circumstance. For example, Calot uses a position of flexion 70°, abduction 70°, and rotation nil. He admits, however, that one is sometimes obliged to adopt the Lorenz position at the outset, since in the position usually employed by him the head will not remain stable. The disadvantage of the Lorenz position is that reluxation anteriorly is rather favoured. Yet even this is not entirely a disadvantage,

[1] The limb is hyper-extended when the knee is behind the patient's frontal plane. When the limb is so abducted that the knee reaches nearly to the axilla, Lorenz describes it as being in a position of negative abduction.

and the fact that the head tends to protrude anteriorly results in stretching of the anterior capsular wall. This latter is a most important and essential point of Lorenz's method, yet it follows that this distension of the capsule in front must be kept within bounds.

The advantages of the abducted position with the axis of the knee sagittal are twofold. Firstly, it is the position of stability; and, secondly, it is that in which both the abnormally contracted and the abnormally stretched peri-articular structures can be induced to transform favourably.

The first bandage[1] is then applied so as to secure fixation in the position described. This is done except when the surgeon is convinced, from his experience gained during the reduction, that even an immediate and temporary exaggeration of the abduction or hyper-extension is advisable. We shall have to refer to this point again under the "second bandage," but it is dealt with more conveniently there.

So much for the position of the limb. We must now speak of the bandage. What is to be its form? Is it to include the whole limb, with the ankle and foot? Is it to go below the knee? Or should it be arrested above that joint?

These three forms of bandage are known as the long, the intermediate, and the short. Which is used depends upon the surgeon's views as to the value of ambulatory treatment.

Lorenz believes that the development of the acetabulum is favoured by permitting the patient to hobble about on the limb as early as possible. To utilise the effects of body weight upon and function of the part during progression, the knee must be left free. He ceases bandaging, therefore, just above the femoral condyles. His view is that the hip-joint alone should be fixed, and that other joints, including those of the lumbar spine, should be left free for compensation. Such a bandage must be well and carefully modelled to the variations of the surface of the parts. It must be skilfully moulded to the outlines of the limb. Many surgeons include the knee, so as to control rotation, but Lorenz holds that the position of the thigh is sufficient for this purpose, and inclusion of the knee merely impedes progression. We ourselves feel that if rotation is not a marked feature, the Lorenz short bandage is sufficient, but if the control of rotation

[1] Some writers speak of a first position, second position, and so on; it is better and simpler to speak of first bandage, second bandage, and so on.

is desired, according to its degree we continue the bandage downward, in extreme cases applying it round the ankle and foot.

Method of Applying the Bandage.—A convenient way of clothing the limb is by drawing on the sleeve of a jersey. Between the jersey and the skin a strip of bandage is passed to serve as a rubber or "scratcher" to the skin. The bony prominences are protected with cotton wool, and the plaster bandage applied (Fig. 156). In order to facilitate the application of the plaster, the patient's pelvis, the lower part of the chest, and the shoulders are on supports. The pelvic "rest" is fixed to the end of the table, and the patient's legs are held by an assistant.

The limb should be taken charge of, either by the surgeon

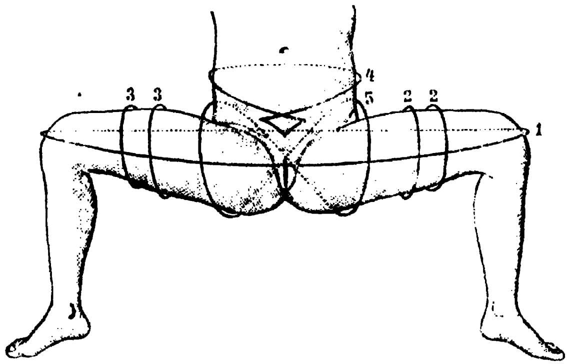


FIG. 156.—Diagrams of the turns of the Plaster Bandage (Lorenz). 1, First turn of the bandage; 2, Spirals of left thigh; 3, Spirals of right thigh; 4 and 5, Figure-of-eight turns around pelvis and thighs.

himself or by a skilled assistant, to ensure that the reduction is maintained while the bandage is being applied and is setting. If relaxation occur during the process, it will not then pass unperceived. Should this accident happen, some surgeons effect reduction again through the soft plaster, but that is not very safe, as the creasing of the plaster may cause pressure and sores.

When the bandage is sufficiently dry and hard, the edges are pared down, and, later, the margins of the jersey are turned round the edges of the plaster and fixed in place, to prevent the child from displacing it (Fig. 157). The sacral region is well packed with cotton wool tucked in under the plaster. As this becomes soiled it can be pulled out and changed. Hoffa painted the plaster bandage with a solution of rubber, so as to render it impermeable.

Inclusion of the knee may lead to stiffening of the joint.

More often, owing to the wasting of the muscles, the knee becomes flail-like for a time. It has been pointed out that when reduction has occurred the knee is partially flexed, owing to the tension of the hamstring muscles. If the knee is left free, these muscles can be stretched daily by passive movements, as advised by my colleague Mr. Jackson Clarke.[1]

After the operation the patient experiences considerable discomfort, and even pain, and may be somewhat sleepless for a night or two. This passes away, however, and the patient readily adapts herself to the new conditions (Fig. 158).

Duration of First Retention.—Here again no hard and fast

FIG. 157.—The Limb in the "First" Plaster Bandage after Reduction of a Unilateral Dislocation. Note the "rubbers" for the skin (Lorenz).

rule is possible. If the position in which reduction has been attained is exaggerated, the bandage must not be left on longer than two or three weeks, because it is found that forward dislocation is almost certain to result; but if abduction to 90° only is adopted, there is no particular necessity for changing the bandage early, unless the surgeon desires the opportunity of inspecting the joint, or the bandage becomes badly soiled. It is a fact that cases have been treated and cured with one bandage only. Nevertheless, the risk of anterior dislocation occurring when anteversion of the neck exists, the possibility of rigidity supervening in older patients, or the chance that negative or axillary abduction may be required for a time, render it unwise to defer the removal of the first bandage beyond six weeks. The importance of the points mentioned here will appear presently.

[1] *Lancet*, March 9, 1907. Also *Cong. Dis. Hip*, London, 1910.

The question then is: Is the first position, or the position in which reduction has been secured, to be maintained throughout the whole fixation period, or can it be modified advantageously as time goes on? We will put this question in another way. On removal of the first bandage, what indications are there to guide us in subsequent procedures?

It may be found that, after removal of the first bandage, in one patient, the hip is rigid to a considerable degree, and in another patient, in spite of correct reposition, a certain looseness is present. If the laxity of the joint is marked, diminution of the abduction is to be carefully avoided on account of the danger of reluxation, and in this case there must be refixation in the first position of reduction.

FIG. 158.—The "First" Plastic Bandage, the patient standing and wearing a boot with a thick sole to compensate for the apparent shortening (Lorenz).

A change of position may be made under the following conditions:—

1. On finding that the head is concentrically placed, but that there is such an amount of rigidity present that difficulties threaten to arise in bringing the leg down to the parallel position in the after-treatment, that is, when the bandage is left off altogether.

2. On finding that the head is eccentrically placed.[1] As a rule it is found in one of two situations:—

(*a*) It is felt to be too prominent in the groin, that is, forward subluxation has occurred. This arises either, *a*, from the bandage having been applied with the limb too much hyper-extended,

[1] As a matter of fact, when the first bandage is removed a considerable number of reluxations will be met with—Lange states 10 per cent at least. In the various writings on the subject stress is not laid on this point, and it is only on reading between the lines that one sees how general this result is.

i.e. too far behind the frontal plane, or β, from the presence of anteversion of the neck.

(*b*) The other position in which the head is sometimes found is on the upper border of the acetabulum.

If then the joint is lax, or if none of the indications mentioned in (1) and (2) are present, the second bandage is applied in the original rectangular abducted position, and abduction is not sensibly diminished during the fixation period.

It should, however, be lessened: (*a*) If there is much rigidity, and the older the child is the more wary one must be on this point; (*b*) If there are any paretic or paralytic symptoms; (*c*) If the head is too prominent in the groin, the thigh is to be slightly flexed and abduction diminished. At the same time the head is pressed back a little through the tissues of the groin, and Calot's position of 70° flexion and 70° abduction adopted (Plate XV., Fig. 1). When the threatening anterior luxation is due to marked anteversion of the neck, not only must the abduction be diminished, but the thigh must be rotated in until the neck assumes a position approximately frontal. It may be that in extreme cases rotation inwards through a quarter of a circle will be called for, so that the toes point completely inwards. I have on several occasions found this necessary. In these cases the long plaster bandage, including the leg and foot, affords the necessary control (Fig. 159).

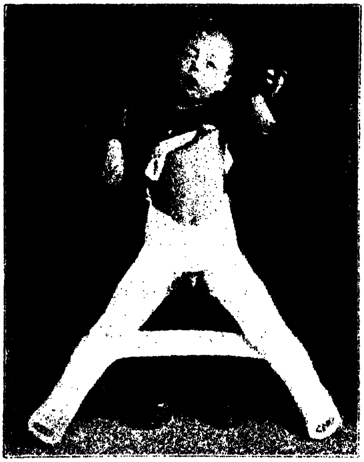


FIG. 159.—Bilateral Dislocation of the Hip, with considerable Internal Rotation of the limbs. The bandages cover the lower limbs and include the feet, so as to control the rotation (Lorenz).

The limb is kept in this position until reduction is stable. This of course leaves the inward rotation to be dealt with. It may be necessary to osteotomise the femur below the trochanters, and rotate the knee to the front.

This may be done in several ways.

1. Schede drove a long, gilded, bayonet-shaped nail through the great trochanter and along the neck in the direction of its axis (Plate

PLATE XVI

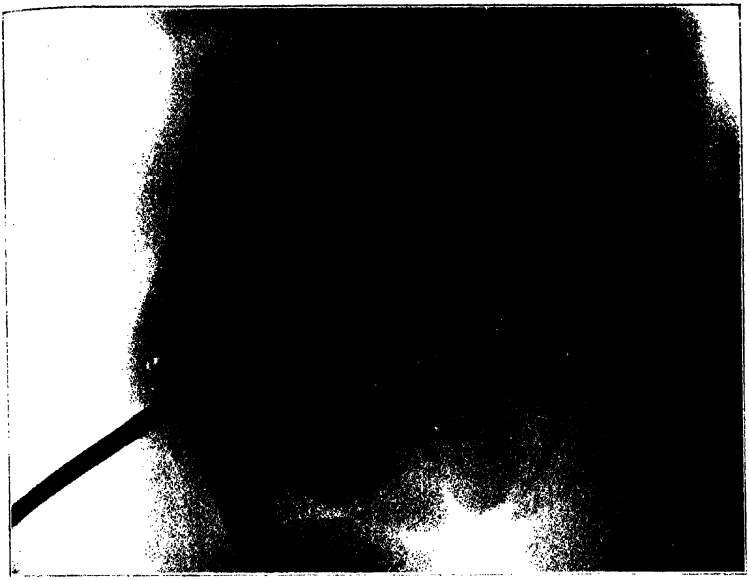


FIG. 1.

Skiagram of Schede's Operation, designed to overcome excessive inward rotation of the limb after reduction of the dislocation (Lorenz and Reiner). For explanation see text.

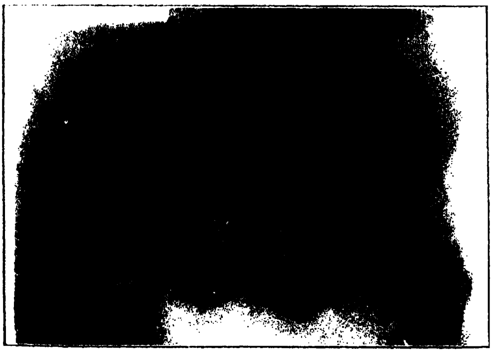


FIG. 2.

The 'Clear' Band in the (Reduced) Left Hip between the head of the femur and the floor of the acetabulum, due to thickening of the soft tissues in the latter situation, contrasts with the close approximation of these bony structures on the right side (Lorenz and Reiner).

To face page 192.

XVII., Fig. 1). Its projecting head serves as a handle to control the position of the upper fragment. E. H. Bradford has used a knitting needle, sharpened to a drill point. The femur is osteotomised below the trochanters, or better still at a hand's breadth above the condyles.

FIG. 160.—Werndorff's Axillary Position. For the ... ons in which it is employed, see text (Whitman).

n correction is made and the limb is enclosed in plaster. After weeks the nail is withdrawn.[1]

Lorenz (*Amer. Jour. Orth. Surg.*, Jan. 1905, p. 227) says: "I have never as yet ied out Schede's osteotomy. In several cases which have been treated by primary ard rotation and subsequent osteotomy I have seen very bad results from the treatment, owing to posterior reluxation. Bradford and Lovett (*ibid.* p. 507) say that the importance of the femoral twist has been much exaggerated, and that Mikulicz and ller have found by investigation that a femoral twist may exist to a considerable nt without causing noticeable disability. In very severe cases, where osteotomy t be done, they advise using a Gigli's saw, and do not entirely divide the bone, but are the part undivided by the saw, so as to leave a sort of splint. Reiner says otomy is indicated in 5 to 8 per cent of cases.

2. Calot performs an osteotomy just above the adductor tubercle.

3. Codivilla drives the nail in, rotates inwards, and applies plaster. Ten days later he cuts away the plaster to the lower third of the thigh, osteotomises, rectifies the limb, and makes the bandage good again. This appears to the author the safest procedure.

If, on removal of the first bandage, subluxation upwards is threatened, a good plan is to refix the limb temporarily in Werndorff's[1] axillary position (Fig. 160). The thigh is abducted, the knee being brought towards the axilla, and retained there for about six weeks by means of a bandage encircling the limb and trunk. In this position the head of the femur is well placed in the acetabulum, and the upper portion of the capsule is afforded a good chance of contracting. This axillary position is particularly valuable as a temporary measure in cases of marked anteversion[2] of the neck when dislocation above and forward is threatened.

If redislocation backwards or upwards is threatened or is present, fixation for a time in hyper-extension may be required, the knee being below the plane of the table.

The position, then, for the second bandage may be a repetition of the position of flexion during the first; or the first position having been that of hyper-extension, or negative abduction for exceptional reasons, the limb may now for the first time be brought into the Lorenz position. The second fixation may be a relatively brief one in a position of hyper-extension or of axillary abduction, or for the reasons indicated it may be one of diminished abduction, with or without inward rotation. Finally, the second bandage has been dispensed with altogether.

It is therefore unnecessary to dilate at length as to how long the second bandage is to be kept on, or what is to be the position of the third or fourth bandages. Treatment must be carried out on the principles already laid down.

A few words are needed on the total duration of fixation. Too prolonged bandaging may lead to contraction of some muscles, or loss of mobility or excessive atrophy of others; but, if the period is too short, relapse may occur. To a certain extent the risks entailed by prolonged fixation may be minimised by changing the bandages more frequently, so as to examine the part.

The length of fixation is determined, not only by the actual

[1] *Ztschr. f. orth. Chir.* Bd. xiii. Heft 4.

[2] Anteversion of the neck may be treated by (1) Abduction reduced to 60°, with the limb rotated inwards and subsequent osteotomy; or (2) by axillary abduction.

condition of the part, but by the surgeon's intentions as to after-treatment. If he means, on removal of the bandages, to bring down the limb parallel to the other quickly, the period must be a long one. If, however, there is to be no prompt rectification the duration may be shortened. It is shorter still if the surgeon is content merely to leave the patient in bed, and wait until a desire is shown to use the limb. As a rule, two or three weeks elapse before the patient manifests any attempt at active movement of the part. This refers to bilateral cases. In unilateral cases the child naturally bears the weight on the sound limb, and tentatively uses the other almost at once. Movements at first are rather in the direction of abduction, and not of flexion and extension, as in health. As the limb comes down, *i.e.* in the frontal plane, rotation of the knee often becomes obvious, but we have to be content with the fact that stability under weight-bearing is secured. It is sufficient at any rate that fixation is absent at this time.

There is one point which has been omitted in the discussion of the treatment of unilateral cases. That is, after the bandage has been applied, and the patient allowed to get up, a thickening must be applied to the sole of the foot on the affected side to compensate for the shortening of the limb due to flexion at the hip and knee. The thickening varies from one to three or four inches. The outer border of the sole must be $\frac{1}{8}$-$\frac{1}{4}$ in. thicker than the inner. In negative abduction a thick sole is not enough; some form of support running up to just below the head of the tibia is required. The patient is able to get about—somewhat awkwardly, it is true—with the affected limb abducted and the pelvis tilted downward on that side (Fig. 158). The above remarks apply to the treatment of unilateral cases.

The Treatment of Bilateral Cases.—So far we have dealt only with unilateral luxation, for the sake of simplicity, and it lends itself more readily to treatment than bilateral. When one limb only is fixed in abduction the pelvis is lower on that side, and the body weight is thrown more directly over the femoral head, conditions more favourable to the effect of usage on the part. We cannot satisfactorily treat bilateral cases by curing first one side and then the other, because the joint first cured will in all probability relapse by being thrown into adduction during the treatment of the second.[1]

[1] We have mentioned (p. 127) that often one side is actually dislocated and the other is predisposed thereto; and during the treatment of the dislocated limb in abduction the predisposed one dislocates, owing to the evil effects of the long-continued adduction.

Again, if the joints in bilateral cases are treated consecutively, one has to consider the ill effects of the great length of the treatment.

It is therefore better to reduce both limbs at once. Still the fact must be recognised that in bilateral cases, if treated simultaneously, one must be prepared to be satisfied with a less complete anatomical cure than in unilateral cases, since practical conditions prevent the carrying out of such complete individualisation as in treating one joint at a time. The rule then is to reduce both joints at one sitting if possible, and the limbs run simultaneously through the same stages of treatment and after-treatment, which is therefore much simplified, and an approximately normal gait is sooner obtained. It must not be thought, in spite of the extraordinary position necessitated when both thighs are in the Lorenz position, that absolute helplessness persists for long. The children soon learn to get about with the help of a stick. The details of the treatment of bilateral cases are the same as those fully described for unilateral cases.

After-Treatment.—Naturally, on removal of the final bandage, however satisfactory the state of affairs may be from the operator's point of view, the condition leaves much to be desired in the eyes of the parents. There will be, even in absolutely successful cases, wasting, limitation of movement, and lameness. It is true that so long as one is certain that the reduction is good we may regard these details as relatively unimportant and likely to disappear spontaneously with the lapse of time. However, after-treatment of some kind should be adopted, because the risk of relapse can be met and combated. Further, by ensuring rapid development of muscles there is less probability of reluxation.

The after-treatment of congenital hip may be described as (1) bringing the limb down from the abducted position to the parallel one; (2) the attainment of movements normal in power and extent; and (3), at the same time the careful conservation and consolidation of the reduction. In actual practice these requirements call for somewhat apparently opposed methods of treatment, and much judgment is necessary. For example, mobility must not be procured at the risk of stability.

We have said that some surgeons attain the parallel position by successive diminutions of the abduction in plaster bandages, while others reduce the abducted position of the limb completely at one

To obviate this, the plan has been followed of fixing the predisposed limb too in abduction, but slight abduction only. This, however, has the disadvantage of interfering with the tilting of the pelvis on the dislocated side.

séance under anæsthesia. Yet this is inadvisable, because reluxation may occur. Others leave the patient alone, the correction from the abducted position being spontaneous, and often one has no option, as the patients are so situated that they have to be sent home, and miss the opportunities for special treatment.

Instead of spontaneous correction of the abducted limb and attainment of mobility by the patient, especially in older children,

FIG. 161.—Position of the patient for Exercises in the Frontal Plane on a table. The nurse holds the pelvis firm, whilst the patient practises abduction and adduction of the limb. The same exercises are done in the prone, and, later, in the standing position (Jackson Clarke).

contractural rigidity may develop. The treatment of such rigidity is by no means easy, for there is much risk of inducing a reluxation in mobilising the part. In many cases, where the position is fair and one side only is affected, it is better not to resort to passive movements.

Lorenz and Max Reiner very wisely point out[1] that the

[1] Lorenz teaches (*Am. Jour. Orth. Surg.*, January 1905) that in unilateral cases abduction is only corrected so far as to permit of easier walking. If during abduction contracture is very rigid, it is gradually overcome by means of a knee gaiter and strap.

attainment of the parallel position is a secondary matter, the important point being to encourage the development of the roof of the acetabulum, and for this a moderate degree of abduction is most valuable. Their method of after-treatment, which is very prolonged, extending from six to eighteen months, may be described as consisting of exercises to strengthen the muscles of the gluteal region, the abductors and extensors of the thigh, and the gradual

FIG. 162.—Passive Exercise after Reduction and Fixation in Plaster; stretching the hamstrings in a case of double dislocation. The left limb is kept in extension by its position on the table, whilst the nurse exercises the right (Jackson Clarke).

diminution of abduction. The exercises used are simple abduction in the frontal plane, the patient at first lying on the back, then, as improvement occurs, on the side, and finally standing (Fig. 161). Hyper-extension is practised with the patient lying on the face;

The strap passes across to the opposite side of the pelvic girdle, and its tension acts in the direction of adduction. In any case correction into the normal position takes many months or a year. He further teaches that the facility of easily assuming again the position in which reduction was first obtained is more important than the correction of abduction, because so long as this is the case we are sure of retaining the head of the femur in its best position for stability.

the spine is hyper-extended, and then the lower extremities. When the patient is at rest an abduction splint, or a plaster of Paris splint, which has been cut so as to be removable, is used to keep up the abducted position.

Rotation outwards of the limb is often very persistent. It must be remembered that the first movements are executed simply in the frontal plane, that is, abduction is increased and diminished on moving, and flexion and hyper-extension cannot be expected for a long time. No very active steps should be taken to hasten the disappearance of abduction for reasons which are obvious.

On removal of the final bandage, children with unilateral dislocation get about much more easily. Besides the active diminution of abduction, they are helped by tilting of the pelvis, whereby the sound limb falls into adduction. A further aid is now afforded by applying the thickening to the sole of the boot on the sound side. As abduction of the affected limb gradually diminishes, this is reduced to $\frac{1}{4}$ in. towards the end of the first year of after-treatment, and is then left off.

FIG. 163.—Stretching the Hamstrings (Jackson Clark)

We have said little about the value of massage and passive manipulations, but here, as in other similar conditions of muscular wasting, these procedures are of the greatest possible use in hastening the return to the normal and towards complete cure.

The flexion of the knee due to tension of the hamstrings after a successful reduction must be overcome (*a*) by stretching them under an anæsthetic about fourteen days after the operation, care being taken not to re-dislocate the head of the femur; (*b*) by daily passive extension of the knee (Figs. 162, 163), and by active exercises. As the muscles become stronger and the knees straighter walking exercises are to be practised.

After the first plaster has been removed, my colleague, Mr.

Jackson Clarke,[1] advises the following active exercises: 1. Abduction and adduction of the limbs several times, carried out first in the supine and then in the prone position. 2. The patient, lying on the sound side, raises the operated limb to the vertical position. 3. The patient, lying prone, elevates both lower extremities by hyper-extension of the spine and hip-joints. 4. The patient, standing with the back against a table on which the hands rest, raises the limbs alternately to the level of the table. A full account of Lorenz's exercises is given by Ashley and Müller in the *New York and Philadelphia Medical Journal*, April to September 1904.

FIG. 164.—An Exercise required in Sub-Spinous cases. The nurse grasps the patient's abducted limb below the knee, which is held back, and steadies the opposite side of the pelvis, then presses her knee at the back of the operated hip, which is thus hyper-extended (Jackson Clarke).

RESULTS OF THE MANIPULATIVE METHOD

There can be no doubt as to the great value of this method. The mortality is very small, or at any rate not greater than that arising from the administration of anaesthetics. Only a small minority of cases show no improvement at all, and the larger number are greatly improved functionally. A considerable proportion must be regarded as both complete functional and anatomical cures; others as functional only. But when we attempt to estimate the relative frequency of "cures" and "functional cures," great difficulty arises because some surgeons are more kindly in the judgment of their own and their colleagues' results than are others. It must be admitted that many of the functional cures show defective gait.

Actual specimens of cured cases are not common, because the

[1] *Loc. sup. cit.* p. 52.

PLATE XVIII.

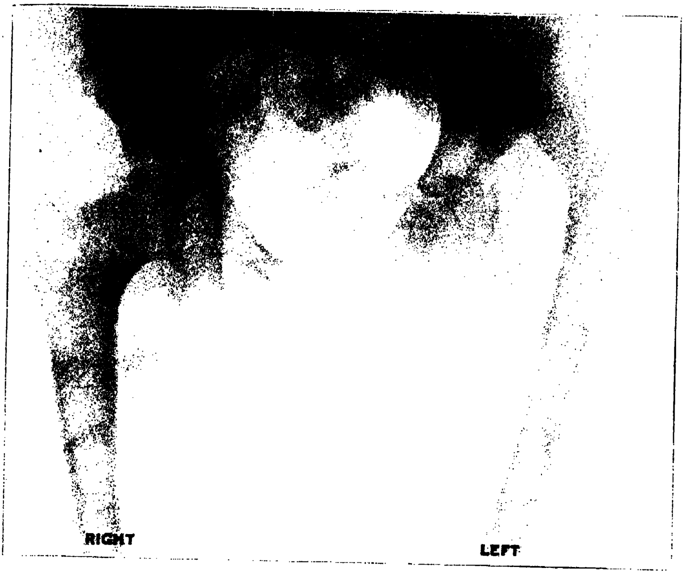


FIG. 1.

Postero-Superior Congenital Dislocation of the Left Hip in a child, aged 4 years, before Reduction.

FIG. 2.

The same hip as in Fig. 1, three months after reduction.

To face page 200.

method is recent and the affection is not fatal. But already a sufficient number of *post-mortem* examinations has been obtained[1] to prove that the terms "reduction of dislocation" and "cure" are justified. These examinations show many interesting points.

In cases where death has occurred as a sequel to the actual operation, the reduction of the dislocation has been substantiated.

Skiagraphic examination of cases in which the reduction is good, that is, the head and acetabulum are concentric, often shows a clear band between the femur and pelvis (Plate XVII., Fig. 2, p. 192). It is found *post-mortem* that this appearance is due to two causes: (1) The acetabular contents are still unabsorbed; (2) The ossification of the acetabular margin is retarded, and being cartilaginous, it appears as a clear band.

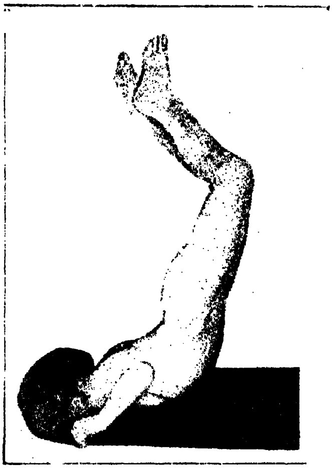


FIG. 165.—Exercise for the Spinal Muscles (Jackson Clarke).

A very important deduction from the specimens observed is that the time taken for the transformation of the capsule and the flattening out or disappearance of the hood or pouch which contained the head is three to four months, and therefore this is the minimum time which should be allowed for fixation.

Even in the most successful cases slight differences from the normal are for a long time capable of detection by the experienced observer. Movements may be normal in every direction, except that abduction is somewhat increased. A slight wasting of the thigh, a flattening of the adductor prominence, a slight fulness in the groin, due to the head not being fully sunk in the acetabulum, or else to the somewhat anterior situation of the cavity, are frequently associated. The trochanter is often somewhat elevated, owing to the short or depressed neck,[2] and often the signs of

[1] Nové-Josserand, *Rev. mens. des mal. de l'enfance*, 1900; *Bull. de la Soc. de chir. de Lyons*, 1901, p. 247. Véan and Cathala, *Arch. de méd. des enfants*, No. 1, 1902; autopsy one and a half months after operation. Ochsner, *Ann. of Surg.* vol. xxxvi. No. 2. Wilson and Pugh, *Amer. Jour. of Orth. Surg.*, February 1904, pp. 247-265. Müller, *Zeitschr. f. orth. Chir.*, 1903, Bd. xi. Heft 2. Allison, *Am. Jour. Orth. Surg.*, Oct. 1905.

[2] This condition of the neck, and a slight atrophy of the whole limb, found in congenital dislocation, entails slight shortening, even in cured cases.

anteversion render it clear that a "cured" case can generally be distinguished from a normal limb. It is a matter reserved for future observation as to whether these signs disappear. From what has been said elsewhere on the relationship between structure and function, it is probable that a truly normal anatomical condition eventually results. An interesting observation bearing somewhat on this point is that of Joachimstal. He habitually reduced one limb at a time in double cases, and has shown that the ossification in the head of the femur on the side first reduced advanced more readily than on the other. That is to say, reposition stimulates the ossification, and therefore the growth and reshaping of the parts.

We may then agree that a perfect anatomical and structural cure is possible, allowing for some slight indications of the past condition, but perhaps even these disappear in time. How often is this happy result obtained?

Calot[1] says: "In the last one hundred reductions performed by us we have had one hundred absolute cures, 96 times from the start, and four times after supplementary treatment, the head having slipped slightly from the cartilage." We have had some little experience of this matter, and find such a statement very difficult to accept. If we contrast Calot's figures with the figures of Kirmisson,[2] regarding cases to the end of 1905, we read as follows:—"The unilateral luxations have been 28 in number. Twice reduction was impossible. Eleven times, or in 39 per cent of the cases, the anatomical results have been good or even perfect. The double luxations are 24 in number, 18 remain available for statistics. In five cases reduction was impossible, and twice only, that is to say in 11 per cent, has a good permanent result been verified."

Lorenz[3] gives 63 per cent of cures in 572 cases up to 1905. Of these cases 296 were unilateral, and the percentage cured was 65·2.

Hoffa,[4] in 315 cases discharged after treatment of over one year, claimed 30 per cent of "real anatomical restorations," with perfect function in 250 unilateral cases, and 64 per cent of anterior transpositions. Of the 65 bilateral cases treated by him only 7·7 per cent showed a perfect result.

[1] *Traitement de la luxation congénitale*, p. 227.
[2] *Rev. d'orth.*, July 1, 1906.
[3] Joachimstal's *Handbuch*, p. 222.
[4] *Am. Journ. Orth. Surg.*, January 1905.

PLATE XIX.

Fig. 1.
Superior Congenital Dislocation of the Right Hip.

Fig. 2.
The Right Hip in Fig. 1, immediately after Reduction.

To face page 202.

Fröhlich,[1] from his personal cases, concludes that the Lorenz process affords radical cure in about 20 per cent, and is palliative in a further 50 to 60 per cent. But, as Lorenz points out, mere statistics of anatomical cure are not everything. The anatomical result may be perfect, the head exactly replaced, yet if the joint is rigid or contracted, the result is functionally bad. More detailed analysis is therefore needed.

Narath has done this in the following table:—

Condition of Joint.	Anatomical Result.				Functional Result.				
	No.		Per cent.		Ideal.	Very good.	Good.	Medium.	Bad.
I. Perfect Reposition	26	39	53·1	79·6	18	5	3		
Excentric Reposition	13		26·5		..	6	7		
II. Subluxation forward and above	5	9	10·2	18·4	...	1	3	1	
Re-luxation forward and above	4		8·2		...	...	3	1	
III. Re-luxation above and behind	1		2·0		...	...	...	...	1
	49		...		18	12	16	2	1

That is eighteen ideal results in forty-nine joints, and only one really bad; and in forty-six cases the functional results were good. But these figures do not give us any information as to how often reduction proved absolutely impossible.

Mr. Jackson Clarke[2] speaks of 75 per cent of cures. Elsewhere[3] he speaks of twenty-four out of thirty cases as cured, or as certain to be cured.

Mr. Burghard[4] does not seem to have been so fortunate with the manipulative method. He says he has tried it in thirty cases, and in only one was there a true permanent reduction.

[1] *Rev. d'orth.* No. 4. 1905.
[2] *B.M.J.* vol. ii., 1905, p. 1589.
[3] *Lancet*, March 9, 1907.
[4] *B.M.J.*, August 29, 1903.

Burghard's method seems to be a compromise between the open and manipulative. While only one case out of thirty was cured by the manipulative method, yet nine out of thirteen were cured by his modification of the open operation, a contrast which will be incomprehensible to most orthopaedic surgeons.

In fairness to those surgeons whose results have been quoted we must make it clear that their statistics have dealt with cases treated in the early half of the last decade. As dealing with large numbers, we refer to Stern's statistics (*N.Y. Medical Record*, Sept. 15, 1906). His figures were gathered from operators all over the world, and very nearly agree with those first given out by Lorenz as his own experience (H. Augustus Wilson, *Therapeutic Gazette*, Nov. 1910). "The number of hips reported as successfully operated on since 1900 is 2593. Ideal results, *restitutiones completae*, 48·98 per cent, *i.e.* anatomical restitutions 1084, or 41·76 per cent; excellent functional results 187, or 7·22 per cent; good function from transposition 1036, or 39·98 per cent; failure, redislocation, bad function 314, or 12·10 per cent." As experience accumulates the results are better in every way. We quote the statistics of E. H. Bradford (*Amer. Jour. Orth. Surg.* vol. vii. pp. 57 *et seq.*), which are very instructive.

Years.	No. of Cases.	Manipulative Treatment.	Cure.	Incision.	Cure.
1896-1902	54	20	1	34	11
1902	22	20	8	2	2
1903	33	32	10	1	0
1904-1906	40	21	10	19	14
1906-1908	61	61	50	. .	. . .

Or to express the facts in another way:—

Years.	Percentage of "Cure" by Manipulation.	By Incision.
1884-1896	0	0
1896-1902	5	. . .
1898-1903	. . .	30
1902-1903	40	. . .
1903-1906	41	73
1906-1908	80 (double dislocation)	. . .
	90 (simple dislocation)	. . .

PLATE XX.

FIG. 1.

Postero-Superior Congenital Dislocation of the left hip in a young child before treatment (Calot).

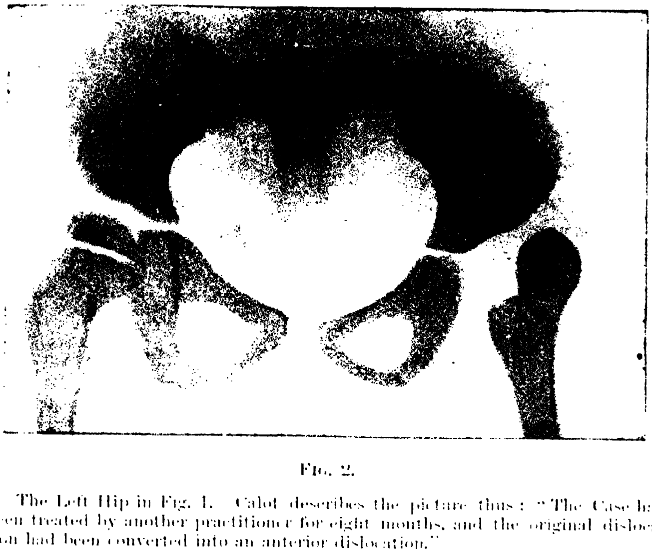


FIG. 2.

The Left Hip in Fig. 1. Calot describes the picture thus: "The Case had been treated by another practitioner for eight months, and the original dislocation had been converted into an anterior dislocation."

PLATE XX. (Continued).

FIG. 3.

The same hip as in Figs. 1 and 2, eight months after reduction by Calot.

The rapid rise in the ratio of successes to failures affords abundant evidence of improvement in technique. By cures is meant anatomical and functional cure.

A perfect functional cure is not possible apart from perfect anatomical reposition, but the latter is not necessarily followed by a completely satisfactory result functionally. On the other hand a sufficiently satisfactory functional result may be obtained without perfect anatomical reposition. Of course, in the nature of things no judgment of results is valid until the lapse of at least a year after the plaster has been removed.

Lastly, the statistics of the individual operator will be affected by the fact of whether or no he rigidly selects his cases, and where he draws the line as regards the *age limit*. With regard to this point, in general Lorenz limits his efforts to the end of the seventh year in bilateral cases, and in unilateral cases to the end of the tenth. Hoffa says from the eighth to the tenth year in unilateral, and from the sixth to the eighth year in bilateral. In patients past these ages real reposition is impossible because of the advanced changes in the position of the parts.[1] In individual cases,[2] however, a yielding condition of the soft parts, a looser state of the ligaments, the slender build of the individual, or other factors, may increase the age limit according to Lorenz, and naturally the converse is true as well.

Accidents, Complications, and Untoward Results

Actual death as the result of manipulation is rare. When it occurs, it is due partly to the shock of the procedure and partly to the prolonged anæsthesia. Deutschlander[3] records four deaths in 1235 cases by various surgeons, either during the operation or within twenty-four hours. In one of Narath's cases death followed three days after operation. Wilson and Pugh[4] publish a very complete account of a fatal case. Doubtless, fatal cases have occurred which have not been published, and G. G. Davies[5] mentions that he knows of two.

[1] *Am. Journ. Orth. Surg.*, Jan. 1905, p. 235.

[2] Blencke (*Zeitschr. f. orth. Chir.* vol. xv. p. 317) obtained a true reduction in a patient aged eleven years, and a functionally satisfactory transposition in one aged thirteen years.

[3] *Zeitschr. f. Chir.* Bd. lxxiii., 1904.

[4] *Am. Journ. Orth. Surg.*, February 1904.

[5] *Am. Journ. Orth. Surg.*, February 1904, p. 267.

Evidently, then, the mortality associated with manipulation, as compared with that of open operation, is slight.

Fractures of the femur and epiphysial displacements are not uncommon. Usually, it is the neck of the femur which fractures, less often the shaft, and displacement of the lower epiphysis is more frequent than of the upper. Rarely, fracture of the pelvis occurs.

According to Deutschländer the statistics of fractures are:—

14	times	in 124	reductions	by Petersen.
13	„	in 480	„	by Lorenz.
5	„	in 124	„	by Julius Wolff.
2	„	in 69	„	by Nové-Josserand.
1	„	in 59	„	by Lexer.

Robert Jones[1] had four fractures of the femoral neck in thirty-eight operations.

As a rule the only inconvenience is the delay entailed until the fracture is consolidated.

Paralysis due to a sudden stretching or tearing of the crural or sciatic nerves has been met with. In the former event the paralysis is temporary and comparatively uncommon.[2] It is due to manœuvres of hyper-extension. Even a complete paralysis of the quadriceps extensor disappears in some months.

Paralysis of the muscles supplied by the great sciatic is more serious. It is due to the tension set up by the traction on the limb, or to compression of the nerve between the femoral head and the pelvis, to over-flexion or to hæmorrhagic effusion between the fibres. Happily it is not as a rule permanent, but such cases have been recorded by Ridlon and Narath. Recovery usually takes place in from six months to two years. Peroneal paralysis[3] appears the most intractable of all, and is often permanent. It has been suggested by von Aberle that this is due to the nerve being so

[1] *B.M.J.*, August 29, 1903.

[2] H. L. Taylor saw it nine times in less than fifty cases. Paralysis of the quadriceps began to recover in all cases in three to four months, but one case of peroneal palsy took longer to recover. There was also one case of complete palsy of the sciatic, in which, three months after the operation, very slight motion at the ankle was observable.

[3] Gocht of Halle states that in about 15 per cent of subjects in the dissecting room the peroneal portion of the sciatic nerve pierces the pyriformis muscle. Thane says that in one of five or six subjects the external popliteal nerve passes through a cleft in the pyriformis muscle. Gocht argues that in the abducted position the pyriformis is stretched and twisted on itself, and compresses the peroneal nerve as it passes through it. He suggests as a remedy tenotomy of the pyriformis tendon.—*Zeitschr. f. orth. Chir.* xiv. pp. 644-661.

tightly bound down near the head of the fibula that the distal portion is unable to take part in the stretching. In only one case of the author's has any form of paralysis resulted, and this was peroneal. Complete loss of mobility and anæsthesia in the parts supplied by that nerve below the knee persisted for six weeks after placing the limb in full abduction. Recovery only commenced when the plaster bandage was removed and the degree of abduction lessened. The paralysis disappeared in nine months.

As to the frequency of paralysis, it was noted twenty-three times in 755 cases operated upon by Lorenz, Petersen, Wolff, and Narath.[1]

Lesions of the blood-vessels are fortunately rare. Lorenz had a case of gangrene of the whole limb, due to thrombosis of the femoral artery, and it is stated[2] that a similar accident happened to a New York operator. The femoral vein was torn by Petersen, but was successfully sutured.

We have already referred to the peculiar form of hernia called after Narath. This cannot be entirely attributed to the operation. It is rather a consequence of the displacement of the ilio-psoas, and during the operation a hernia may make its way through the unprotected spot in the abdominal wall.

Hoffa, at the German Surgical Congress, 1899, stated that he had torn the soft parts, vulva and urethra.

H. M. Sherman[3] relates that he attempted arthrotomy in one of Lorenz's transpositions. On cutting down, he found the head in a subfascial extra-articular location, and surrounded by a pseudo-capsule. Sherman holds that the head is often forced through the capsule in the Lorenz method. Tearing of the capsule, then, is another accident to be borne in mind.

Relapses and Reluxations

Reluxations may occur owing to errors of technique, such as too early diminution of abduction or too short a fixation period. Or it may be that only a pseudo-reduction has been made, the head not having been forced through the narrow part of the capsule.[4]

[1] Joachimstal's *Handb.* p. 218. [2] *Ibid.* p. 217.

[3] *Amer. Jour. Orth. Surg.*, Jan. 1905. p. 249.

[4] It has been suggested by some that the capsular isthmus is too narrow to allow the head to pass through. It is presumed that it cannot be stretched, and that the head is simply placed near the acetabulum with the capsule intervening, but the *post-mortem* examinations already referred to show that this is not so. Thus, in the

Or possibly a hypertrophied ligamentum teres has been present, so that a great thickness of soft parts intervenes between the bones. Extreme deformity of the head or the presence of exostosis in the acetabulum are rather causes of failure to reduce than of reluxation.

Should posterior reluxation occur, the head may again at once be reduced, or in view of the atrophy of bone engendered by the prolonged retention period, it may be left alone for a few months before a further reduction is attempted.

The chief cause of reluxation, or rather transposition, is anteversion of the neck. This is to be guarded against during treatment by a correct diagnosis made from the first as to the state of the neck, and by the suitable measures during treatment already detailed. But, supposing that during treatment anterior luxation is discovered, we must be guided by circumstances. Thus, in the first degree of anterior luxation, the head receives an efficient support from the pubic bone, and the functional result may be so good that it is well to let matters alone. Even in the greatest degree of anteversion, in which the head looks directly forwards, and is free in the soft parts, Lorenz states that the result is not entirely bad, the iliac bone being supported by an angle of the great trochanter resting in the acetabulum.[1] Treatment of such a case must be based on the lines already laid down, and it is here that axillary abduction as a preliminary measure is of the greatest value.

To sum up: Whenever possible the manipulative procedure must be carried out on the lines indicated, but we have still to deal with those exceptional cases in which it fails or cannot be applied. These can best be discussed under the headings: (1) Manipulation fails, although the patient is within the age limits; (2) The case may be unsuitable, that is beyond the age limit; (3) Relapsed cases; (4) Cases in which all active treatment is refused, or is inadmissible.

1. *The Procedure fails, that is, Reduction is not obtained.*—

(*a*) The limb may be left fixed in the best possible position, that is, with the head as near to the acetabulum as possible, and the attempt may be renewed a few days later. As failure is more often met with in older cases we will refer to this again.

case recorded by Allison he says: "At no point is the joint capsule folded in the cotyloid cavity before the head, and this was seen in a girl aged seven years, who was operated upon."

[1] See also one of Lorenz's cases by A. J. Steele, with figure. The trochanter major is in the socket.—*Amer. Jour. Orth. Surg.*, April 1905, p. 347.

(*b*) Mr. Burghard[1] believes that the cause of failure is interposition of the capsule between the bones. He carries out myorrhexis, stretching of the muscles, and manipulations for reduction. If they fail, a week later he cuts down, opens the joint, and replaces the head, but does not deepen the acetabulum.

In a few cases, undoubtedly, the presence of grave anomalies in the shape of the head of the femur and of exostoses in the acetabulum may be a cause of failure, and can only be detected by open operation. Other surgeons have not had by any means such a large proportion of failures due to "capsular intervention" as Burghard.

(*c*) The Hoffa-Lorenz open operation may be performed.[2] We have already dealt with this. Unless after failure of prolonged and repeated attempts by the manipulative method, few surgeons would now undertake it. In fact its place is limited to those cases well within the age limit in which manipulation has failed, and where the surgeon having been induced to explore, such anomalies are revealed, that intervention has to be pushed beyond mere operations on the capsule. We advise Bradford's or Jackson Clarke's open operations.

2. *Cases beyond the Age Limit, unsuitable for the Manipulative Method*:—

(*a*) The age limit can be considerably raised by attempting reduction in stages. This has been practised by Schlesinger and by Max Reiner.[3] They proceed exactly as if complete reduction were intended, but leave the head pressing against the capsular isthmus. After one or two weeks a second attempt is made, in the hope that the tension set up, with the softening effects of the œdematous reaction, will enable the capsular resistance to be overcome.[4]

(*b*) Lorenz[5] does not favour extension of the age limit, and he says:—

"Putting aside exceptional cases, I still believe that the age of nine to ten years should be the limit of reducible unilateral cases, and seven to eight years of bilateral. In individual cases beyond

[1] *B.M.J.*, August 29, 1903.

[2] The author has performed this operation ten times. The capsule was incised crucially, the psoas tendon divided, the head of the bone put into the acetabulum, and the limb put up in the abducted position. In four of the cases, six years afterwards, the result was excellent, the head remaining in the socket. In six of the cases relapse occurred.

[3] *Centralb. f. Chir.* No. ii., 1904.

[4] Weischer (*Centralb. f. Chir.*, 1904, No. 15) reports a successful case by this method at the age of fifteen years.

[5] *Amer. Jour. Orth. Surg.*, Jan. 1905.

the age-limit, reduction has been effected after repeated sittings, but the reduced joints become so stiff as to simulate functional ankylosis." He favours transposition. The question is, Does the head stay in the position? Kirmisson says probably not, and with this we agree. Lorenz calls this method of dealing with the displaced head "inversion." The treatment deserves a fair trial, and in any case no harm is done.

(*c*) In cases beyond the age limit, adduction may be so marked that the knees are actually crossed in walking, or it may be altogether impossible. Kirmisson[1] has dealt with such cases by subtrochanteric osteotomy, and is still in favour of this method. Fröhlich reports that Kirmisson's operation corrected the adduction and lordosis, much improved the walking and standing power, and enabled the patient to keep clean.

Osteotomy in congenital dislocation is no new thing. Makins[2] performed a double subtrochanteric osteotomy in a girl aged six years, who previously to the operation was unable to walk, and subsequently walked well.

Lorenz disapproves entirely of osteotomy, as it induces an angle, and thus adds to the shortening of the limb. Osteotomy, however, is sometimes forced on the surgeon on account of the extreme deformity. Blencke had to perform it twice in 154 cases on account of the extreme adduction. Both cases were in women twenty-five years of age.

(*d*) Before doing anything radical there is no reason why simple myorrhexis, or excision of a portion of the adductors, should not be done, with the limb fixed in abduction, without actual reduction.

(*e*) Another plan is the pseud-arthrosis method of Hoffa. In this the head of the bone is removed entirely, the ilium scraped bare, and a pseud-arthrosis made. Hoffa[3] stated that ankylosis does not follow, and in more than fifty cases he had very good results. The author also had one case where it was necessary to excise the head of the bone because of its extreme deformity.

(*f*) Attempts have been made to limit by various operative procedures the ascent of the head of the femur. We have already dealt with these in the historical summary (p. 128), and refer the reader thereto.

3. *The Cases may Relapse.*—Of this accident we have already spoken at some length, and we may summarise as follows:—

[1] *Rev. d'orth.*, Sept. 1906, p. 468.
[2] *B.M.J.*, 1895, vol. ii. p. 365.
[3] *Amer. Jour. Orth. Surg.*, January 1905, p. 268.

(*a*) Errors of technique may have been present, therefore try again. Hoffa stated that he would give the bloodless method three trials.

(*b*) Schede's procedure (p. 192) may be called for.

(*c*) In the absence of any indications as to the causes of the relapses an exploratory operation may be undertaken, and (1) some serious anomaly, *e.g.* exostoses of the acetabulum, may be found; (2) the contraction of the capsule may be too great to permit the head to pass. E. H. Bradford has paid particular attention to this point. He lays bare the capsule, incises it posteriorly, and explores the acetabulum by means of an electric light enclosed in a sterilised test-tube. The split capsule is held apart by retaining sutures, whilst the head is placed well home in the acetabulum. The sutures are then tied round the great trochanter, thus holding the head in place.

4. *All Active Treatment may be refused or be inadvisable.*—In this case the only method left to us is to supply a walking apparatus from the ground to the pelvis, with steel rods on the inside and on the outside of the limb. The inner rod is expanded at its top, so as to form a crutch, which presses on the tuber ischii, transmitting the weight of the body to the ground. Opposite the knee the rods are jointed, and by means of a ring-catch the knee can be stiffened at will, so that when the patient stands, the body weight is transmitted through the tuber ischii straight to the boot, to which the rods are fixed below. If extension racks are placed in the thigh pieces, the apparatus can be lengthened as the child grows, and continuous pressure maintained on the tuber ischii.

It is bad policy to order a high boot alone. In itself it does no good, and merely causes the head of the bone to be displaced upwards more readily.

Congenital Dislocation and Subluxation of the Ankle

These deformities are evidently very rare. The majority of authors do not refer to them at all.

Bradford and Lovett merely state that they "have been recorded in connection with absence of the tibia or fibula."

Freiberg records one (*Am. Jour. O. S.* vol. i. 1903-4, p. 335) which he calls "A unique case of congenital luxation of the ankle"—"unique" because both fibula and tibia are present in their entirety.

A. Dreifuss relates a similar case (*Zeit. f. orth. Chir.* xvi. pp. 420-435) which he calls "Ein Fall von v. Volkmannscher Sprunggelenkmissbildung."

From the study of these and other cases it would appear that they may be classified as—

I. The ordinary form of subluxation, or luxation met with in congenital deficiency of the fibula. Absence of the fourth and fifth toes is often seen, and the foot is in the position of equino-valgus.

II. Volkmann's congenital ankle deformity. The development of the fibula is rudimentary, and an hereditary history is frequent. The foot is complete, and is luxated more or less outward.

III. The cases of Freiberg and Dreifuss, in which the external malleolus is present, but is situated above, or above and behind, its normal position, with the result that the ankle-joint cleft is oblique, the foot luxated out, and much pronated or valgoid.

IV. Cases in which the tibia is defective, and the foot is luxated inward in varus or equino-varus.

I have also met with a striking example of spurious congenital dislocation of the ankle forwards, due to an abrupt curve backwards of tibia and fibula at their lower ends.

Treatment is very unsatisfactory. Tenotomy and retention of the parts in splints is advisable in infants. When the child is older a portion of the tibia may be split off to fill the gap in the fibula. If this fails, arthrodesis is advisable in children over eight years of age, and I have always fixed the os calcis, astragalus, and tibia together, by a long screw driven vertically upwards through the heel, and left in as long as possible, even for twelve months, the part being retained in plaster of Paris.

References.

A. H. Freiberg. Am. Jour. Orth. Surg., May 1904.

A. Dreifuss. Zeitschr. f. orth. Chir. xvi., 1906, p. 422.

L. Burckhardt. Jahrb. f. Kinderheilkunde, 1890, Bd. xxxi. S. 375.

R. Volkmann. Deutsch. Zeitschr. f. Chir., 1873, Bd. ii. S. 538.

Kraske. Verhandl. der deutsch. Gesellsch. f. Chir., 1882, S. 126.

Bidder. Verhandl. der deutsch. Gesellsch. f. Chir., 1888, 2 S. 92.

Faler. Inaug. Disser. Halle, 1884.

CHAPTER VII

CLUB-FOOT—GENERAL CONSIDERATIONS

Varieties and Causation of Club-Foot—Its Frequency—A Method of Examining Club-Foot—General Principles of Treatment—Wolff's Law

Synonyms—Latin, *Talipes, Pes Contortus*; French, *Pied Bot, Stréphopodie, Kyllopodie, Kyllose*; German, *Klumpfuss.*

BEFORE we describe the congenital forms it is advisable to discuss club-foot in general.

Definition.—The term club-foot comprises those deformities in which the anatomical relations of the foot to the leg, or of one part of the foot to the other are abnormal. By many surgeons the meaning of club-foot is restricted to the deformity known as talipes equino-varus whether congenital or acquired, but some surgeons still use the term "club-foot" to express collectively all varieties of talipes.

Inasmuch as the foot is capable of the following movements, dorsi-flexion (flexion) and plantar-flexion (extension), adduction with inversion (supination), abduction with eversion (pronation), and talipes is associated either with over-action or loss of action of one or more groups of muscles affecting these movements, we have—

1. *Talipes equinus*, or the plantar-flexed foot; 2. *Talipes calcaneus*, or the dorsi-flexed foot;	the centre of motion being mainly at the ankle-joint.
3. *Talipes varus*, or the adducted and inverted or the supinated foot; 4. *Talipes valgus*, or the abducted and everted or the pronated foot;	the centres of motion being at the ankle and medio-tarsal joints.

Further, the convexity of the plantar arch undergoes a diminution at each contact of the foot with the ground, and when the foot is raised, a restoration. Hence two more varieties must be added, viz.—

5. *Pes cavus*, in which the convexity of the longitudinal arch of the foot is increased. It is better to subdivide this form into *talipes arcuatus* and *talipes plantaris*, according as the front part of the foot is on a level with or below that of the heel; it being understood that in each case there is a distinct increase in the convexity of the arch.
6. *Pes planus*, in which the arch is flattened to a varying degree.

Clinically, it is found that such a simplicity of arrangement does not always prevail. Frequently the deformity is compound in its character. Thus talipes equinus and varus are often combined, and talipes calcaneus and valgus. The compound forms in their order of frequency are—

1. *Talipes equino-varus.*
2. *Talipes calcaneo-valgus.*
3. *Talipes equino-valgus.* } Uncommon.
4. *Talipes calcaneo-varus.* }

So as to be in accord with all recent descriptions, it is well to add the following table of distortions of the foot—

I. Club-foot—(*a*) congenital, (*b*) acquired varus and equino-varus.
II. Valgus and calcaneo-valgus.
III. Equinus.
IV. Calcaneus.
V. Equino-valgus.
VI. Calcaneo-varus.
VII. Pes cavus—(*a*) arcuatus, (*b*) plantaris.
VIII. Acquired flat-foot.

Taking 903 cases of club-foot from his hospital work, the author finds the varieties as follows—

	Cases.
Talipes equino-varus	382
Talipes equinus	125
Talipes calcaneo-valgus and equino-valgus	104
Talipes varus	77
Talipes valgus	74
Talipes plantaris	57
Talipes calcaneus	47
Talipes arcuatus	37
	903

The Causes of Club-Foot may be summarised :—

I. *Congenital.*

II. *Acquired.*

1. Paralytic, as a result of acute anterior poliomyelitis (infantile paralysis), spina bifida and peripheral neuritis.
2. Spastic, as a result of infantile hemiplegia, paraplegia, cerebral diplegia, and lateral sclerosis.
3. Cicatricial, the result of burns. Talipes calcaneus is sometimes due to deep burns on the front part of the foot.
4. Traumatic—
   (*a*) Injuries to bones, *e.g.* fractures and separation of the epiphyses.[1]
   (*b*) Injuries to joints. Schwartz [2] alludes to unreduced dislocation of the ankle-joint as a cause.
   (*c*) Injuries to tendons. A ruptured tendo Achillis, badly treated, results in talipes calcaneus.[3]
   (*d*) Injuries to nerves. This subject will be dealt with under paralytic affections.
   (*e*) Injuries to muscles such as result in ischæmic paralysis.
5. Inflammatory. After acute osteo-myelitis of one of the bones of the leg, the rate of growth may be arrested in one bone, while in the other it is normal, and the foot is turned into the position of either valgus or varus. Chronic osteitis has been known to produce a like result, but in a different way. The growth in the healthy bone is normal, while in the diseased bone it is excessive. Abscess in the calf and arthritis of the ankle and foot are causes of distortion also.
6. Talipes decubitus—a spurious form of contraction which occurs in bedridden patients from the "dropping" of

[1] I have five times seen cases of valgus following fracture of the lower end of the fibula in young subjects, in whom the natural rate of growth at the lower epiphyses was arrested, while the tibia continued to increase in length, and pushed the foot outwards.

[2] *Des différentes espèces de pied bots et leur traitement*, Thèse d'agrégat, Paris, 1883.

[3] I have also seen six cases of calcaneus which followed equinus, and due to excessive elongation of the tendo Achillis after division. The usual history is that the patient was allowed by the surgeon to walk about "a week or two" after the operation.

the feet and the weight of the clothes. It is best marked and most intractable in alcoholic paraplegia.

7. Hysterical paralysis or contraction.

Of the acquired forms the paralytic and spastic varieties are immediately due to abnormal muscular action, and are common; while the others are rare, and may be termed spurious talipes. In the production of talipes we must remember that the rôle of the muscles presents itself under two aspects.

(*a*) In spastic cases, a group or groups of muscles are contracted, while their opponents are of normal or slightly lessened tension. The foot is therefore pulled into an abnormal position *corresponding* to the action of the more tense muscles. If an attempt be made to replace the foot, it is either entirely resisted or partial restoration alone can be effected. When the force is removed the foot "flies back" to the deformed position. In these cases, then, the direction of the deformity is in the line of action of the affected muscles, *e.g.* spastic talipes equinus from contraction of the calf muscles.

(*β*) In paralytic cases, a group or groups of muscles are paralysed, while their opponents are of normal strength. The foot is therefore pulled in a direction *opposite* to that of the affected muscles, *e.g.* paralysis of the muscles on the front of the leg and of the peronei causes talipes equino-varus.

Frequency of Club-Foot and its Varieties.—Club-foot is a common deformity. Mr. F. R. Fisher[1] tabulated 3000 consecutive cases of deformities which had come under his notice. The analysis showed that club-foot occurred in 581 cases. In my hospital practice, of 5079 consecutive cases of deformity, club-foot was present in 903. When taken in comparison with other surgical affections, it is of rare occurrence. Rédard[2] estimates that in 1000 surgical cases 4 of club-foot are met with. Dieffenbach admits that one instance of congenital club-foot is found in every 800 to 1000 cases. In 23,932 new-born infants Chaussier found 132 deformities, and of these 35 were cases of talipes. Of 15,229 births occurring at La Maternité de Paris, Lannelongue[3] noted 108 cases of deformity, and 8 of these were club-feet. Hoffa found 171 cases among 1444 deformities, *i.e.*, 11·8 per cent.

It is said that congenital club-foot is more common than the acquired, but this I venture to doubt. Of 1263 consecutive cases

[1] Ashurst, *Encyclop. of Surg.* vol. vi. p. 1003.

[2] *Op. cit.* p. 622.

[3] *Du pied bot cong.*, Thèse d'agrégat, Paris, 1869.

under my care, 544 were congenital. Sydney Roberts'[1] statistics support my view, viz. 173 congenital cases against 223 acquired. Whitman,[2] Waller and Weingarten collected 4718 cases of talipes; 2103 were congenital, and 2615 were acquired. Of 2103 instances of congenital talipes, 1355 occurred in males, and 748 in females. Of 2613 cases of the acquired form, 1416 were in males, and 1199 in females. In each form the right foot is deformed more often than the left, and in congenital talipes the deformity is as often bilateral as unilateral, while in the acquired form the affection is generally unilateral.

Heredity.—Many surgeons have observed that club-foot runs in families. W. Little[3] instanced a case of hereditary transmission through the male side for four generations. This fact is of great importance in the discussion of the immediate causation of club-foot. Adams[4] mentioned a case in which the deformity persisted through three generations, and Rédard refers to a similar instance. Not only is club-foot hereditary, but the particular form reproduces itself in the children. With congenital club-foot other deformities are frequently found, such as polydactylism, club-hand, hare-lip, and spina bifida.

In dealing with talipes it is necessary to determine the form, and then to ascertain the cause. A description will therefore be given of a method of examining club-feet.

A Method of Examining Club-Feet.—To some a club-foot is a club-foot and nothing more. But it is imperative before commencing treatment not only to ascertain which *form* of club-foot is before us, but also to be precise as to the *cause.* It is therefore our endeavour to draw out a rough plan of the usual method of examination, and to give illustrations in point as far as possible.

The various steps of the examination are:—

1. The history.
2. The gait on entering the room.
3. The position of the foot and limb on standing and sitting.
4. An outline or impression of the sole of the foot.
5. General examination of the affected limb or limbs as to shape, size, muscular development, diminished or excessive mobility of the joints, the temperature of the limb; the condition of the

[1] "Club-Foot," *Phil. Med. News*, March 1886.
[2] *Orthopedic Surgery*, 3rd ed., 1907, p. 760.
[3] Holmes, *System of Surgery*, 3rd ed. vol. ii. p. 232. [4] *Op. cit.* p. 218.

skin as to colour, integrity, and the presence of corns or thickened skin over the heels and beneath the balls of the toes. The boots should also be looked at, and any unequal wear in places be noted.

6. The passive movements which may be effected by the surgeon, and the directions from which resistance is felt.

7. Localisation of the resistant ligaments and fasciæ, and of

8. Contracted or paralysed muscles. This is effected by touch, by movement on the part of the patient, and by

9. The electrical reactions of the muscles.

10. Signs of abnormal and arrested development, especially of bones. To proceed to details:—

1. *The History.*—The first question asked is, When was the deformity noticed? Of course in congenital cases, if the deformity is at all marked, it is seen immediately after birth. In slight cases difficulty may arise. Mr. Reeves[1] says, regarding the normal form of the fœtal foot: "In it the plantar arch is but little formed, but it is not flat,[2] the sole of the foot is turned in, and the anterior part slightly abducted, but the peronei are capable of turning the sole outwards. To distinguish the former natural positions from slight cases of club-foot, the infant should be placed near the fire; and if the foot be normal the child will flex the thighs upon the abdomen, the legs upon the thighs, and turn the feet out; but in congenital equino-varus it will not be able to evert the foot." Congenital club-foot is as often double as single. Paralytic club-foot is more often single. In the latter case the information will often be volunteered that the child was quite well until about twelve months old or later, and then it was feverish and had a convulsion; and next morning it was unable to move the limb. In spastic cases, which are often bilateral, some history of asphyxia at birth, or of symptoms of meningitis, an account of a severe illness, or sudden shock is forthcoming. The mode of delivery is often of interest; many congenital cases have been breech presentations or one of twins.

2. *The Gait on entering the Room.*—The "tiptoe" forward gait of spastic cases is characteristic. In infantile paralysis, if the case is one of equinus, the toes are dragged and the heel is raised; if the affection is calcaneus, the heel is brought to the ground with

[1] *Practical Orthopædics*, p. 152.

[2] Spitzy and Dane, *Amer. Jour. Orth. Surg.*, Aug. 1904, p. 120, show that Lorenz and others are wrong in stating that the feet of the newly-born infant are flat. The arches, slight but existing at that time, are masked by the comparatively large amount of fat in the sole.

much emphasis, while the front part of the foot flaps somewhat as the patient advances to take the next step. Some shortening is frequently present in paralytic cases, and evidence of this is seen in the halting gait and the dropping of one side of the pelvis and one shoulder. In congenital club-foot it should be noted which part of the foot comes into contact first with the floor. In equino-varus considerable turning in of the foot and raising of the heel is seen. Weakness of one leg, with the arm held rigid and the forearm pronated and flexed, are suggestive of infantile hemiplegia.

3. *The Position of the Foot and Limb on Standing and Sitting.*—It is essential that the patient be examined in both positions, otherwise errors may be made. For example, in right-angled contraction of the tendo Achillis, when the patient is sitting he can bring the heel to the ground because the calf muscles are relaxed, but on standing with the leg fully extended and the calf muscles tense, the heel may be an inch or more off the floor. Again, some cases which appear to be equino-valgus when the patient is standing, resolve themselves into equinus if the sitting position be adopted with the leg placed at right angles to the knee; for the reason that, with a somewhat short tendo Achillis, in order to bring the heel to the ground in standing, the foot is abducted at the ankle, and the difficulty arising from the shortness of the tendon is thus obviated. Cases of varus should be examined with the patella to the front, and the true position of the foot ascertained.

4. *An Outline or Impression of the Sole of the Foot.*—This may be obtained in several ways: either by applying printer's or ordinary ink to the sole, and directing the patient to place his foot firmly on a sheet of white paper, or by taking a sheet of smoked glass and telling the patient to stand on it; or if an outline only be desired, the sole of the foot may be well moistened with water, and the foot planted firmly on a sheet of brown paper. The outline may be rapidly put in with ink before the impression on the brown paper dries. It is valuable, in cases of arcuatus and flat-foot, to obtain an impression or outline at the commencement and at the end of treatment. In many cases it is essential to have a plaster of Paris cast taken of the limb from above the knee.

5. *General Examination of the Affected Limb.*—The shape of the limb, especially as to muscular wasting, and its development as compared with its fellow, should be noticed. Thus, in congenital and spastic cases, the "swell" of the calf is at a higher level than

in the healthy limb. In infantile paralysis wasting of the anterior or the posterior muscles will be readily seen, so too in the late stages of spastic cases; while the enormous calves of pseudo-hypertrophic muscular paralysis will not escape attention. The bones are often felt to be of less thickness, and not only the leg, in paralytic cases, but also the foot, is shorter than normal.

An excessive mobility at the knee-joint, especially if rotation is free in the extended position, is a factor of importance in the prognosis and treatment of club-foot, both of the congenital and paralytic varieties. Much of the inversion in talipes equino-varus is due to it, and it needs methodical correction. The general inward twist of the whole limb in a spiral manner is to be noted. Equino-varus is an affection implicating not only the foot, but the whole limb. In infantile paralysis a flail-like condition of one or more of the joints will be evident, and the knee may be hyper-extended.

The surface temperature and the colour of the skin, often dusky red or blue, with the presence of chilblains and other signs of imperfect circulation, are characteristic of anterior poliomyelitis, and of those congenital cases in which spina bifida is present. The presence of corns and false bursæ indicates that undue pressure exists at the spots where they are found. Thus in right-angled contraction of the tendo Achillis a row of corns will be found beneath the heads of the metatarsal bones, and the same condition is seen in talipes arcuatus and plantaris. In old-standing cases of equinus the heel is feebly developed and small, and the skin over it quite thin, thus showing that it has not at any time come into contact with the ground. It is well to look at the boots and see if they are worn unequally, especially in the cases of so-called weak ankles.

6. *The Passive Movements which may be effected by the Surgeon.*—In most cases of club-foot the nature of the deformity is evident. But it will happen that in slight cases it is difficult to decide by merely looking at the foot if adduction or abduction is too free, and similarly with extension and flexion. The foot should then be moved passively in all these directions, and the surgeon notes in which position it can be placed with the greatest ease. These movements are carried out with the child sitting, and then the position assumed by the foot in standing is observed.

7. *Localisation of the Resistant Structures.*—The heads of the metatarsal bones being drawn away as far as possible from the heel,

any bands of plantar fascia, standing unduly in relief, may be seen and felt. If any doubt exist, the position of the band may be localised accurately by pressing the forefinger-nail gently on it, and its tension thus quickly ascertained. On account of their depth from the surface it is impossible to identify the contracted ligaments.

8. *Localisation of Contracted or Paralysed Muscles.*—This may be roughly determined by sight and touch. But in cases of infantile paralysis and in spastic and congenital cases it is advisable to put the patient through a form of drill. Thus, when paralytic equinus is present, it is needful to ascertain if any and what degree of power remains in the extensor muscles. The patient, if sitting, should be told to try to raise the toes towards the surgeon's finger, placed at one or two inches above them, the surgeon's other hand holding the foot above the ankle. Then the dorsal flexion of the great toe may be tried in the same way, in order to see if the extensor proprius pollicis has escaped or not. Similarly, in calcaneus an attempt may be made to touch the surgeon's fingers held an inch or two below the toes. To estimate the power of abduction and adduction in the foot, the finger should be placed one or two inches to the outside or inside of the foot. In paralytic cases it is essential to ascertain if paralysis of other muscles of the limb is present, particularly of the quadriceps. In the case of the latter it is not sufficient for the surgeon to place his hand at the level of the patient's knee and tell him to touch the hand with the toes. With one hand holding the condyles of the patient's femur, his thigh should be fixed, while the other hand is held out for the patient to touch with his toes. If there is any paralysis of the quadriceps extensor, and the femur is not fixed when the patient is told to extend the leg, it will be noticed that he first flexes at the hip, and raises the thigh off the chair, thus giving the leg a swing at first backwards and then forwards, the latter movement being mistaken for extension.

9. *Electrical Reactions.*—In cases of spastic paralysis the affected muscles react less to the constant current than normally. While in paralytic cases not only is more current required than normally to obtain a contraction from a given muscle, but if the muscle is much damaged no reaction at all is obtained. In those muscles which are less affected the reaction of degeneration is seen, and the muscle responds for a time more readily to the galvanic current, whilst stimulation of the nerve gives little or no

response; and both the muscle and the nerve fail to respond to the Faradic current. Then, too, in the reaction of degeneration, instead of the order of ease of contraction to nerve stimulation by the constant current being

$$\begin{array}{l} \text{K.C.C.} \\ \left.\begin{array}{l}\text{A.C.C.} \\ \text{A.O.C.}\end{array}\right\} \text{equal} \\ \text{K.O.C.} \end{array}$$

A.C.C. may equal K.C.C., or A.C.C. may exceed K.C.C., and K.O.C. may exceed A.O.C.

10. *Signs of Abnormal or Arrested Development of the Bones.*—In congenital club-foot the presence of excessive inward rotation of the bones of the limb is a point of importance. Absence of the fibula or tibia, or parts of those bones, and a rudimentary patella, are occasional accompaniments. In paralytic equino-varus excessive prominence of the cuboid is an evidence of the duration of the affection.

General Remarks on the Treatment of Club-Foot.—A distinguished orthopædic surgeon (E. H. Bradford of Boston), writing on the treatment of club-foot,[1] remarks: "The literature of the treatment of club-foot is as a rule that of unvarying success. It is often brilliant; . . . and yet in practice there is no lack of half-cured or relapsed cases,—sufficient evidence that the methods of cure are not universally understood. In club-foot, half-cures are practically no cures at all. The great test of the cure of club-foot is the position of the foot in walking. There should not be the slightest attempt to return to deformity at any period."[2] "Cases of club-foot should be watched a long time before pronouncing as to absolute cure."

In undertaking the treatment of club-foot the objects are two: to remove the deformity, so far as the shape of the foot is concerned; to restore completely the functions of the foot and limb permanently.

It is convenient to mention briefly the means of treatment at our command, and in appropriate conditions to apply them to the various forms of club-foot.

These methods are:—

1. Mechanical and Retentive.

2. Physiological—such as douching, massage, passive and active movements, the use of the electric current.

[1] *Trans. Amer. Orth. Assoc.* vol. i. p. 89.
[2] Bradford and Lovett, *op. sup. cit.* p. 460.

3. Operative.

1. *Mechanical Methods.*—The mechanical aspect of the treatment of club-foot has of recent years taken a subordinate place. There are, however, certain degrees of all forms of club-foot to which mechanical methods are applicable. Who, for instance, would divide tendons in the foot of a new-born infant, which, slightly inverted, is yet replaceable by the hand? Or who, in a case of rachitic valgus, would sever the peronei tendons when the arch can be readily restored by suitable apparatus? After operations of all kinds on club-foot, the employment of support, in some form, is essential to complete the case and to prevent relapse, whether it be plaster bandages, metal splints, elastic traction, Scarpa's shoes, or the many kinds of walking apparatus, commonly called "irons."

2. *Physiological Methods, including well-directed Exercises, Douching, Massage, and the Electric Current.*—Phelps has well said that "the best orthopædic machine ever devised is the human hand; guided by intelligence it applies forces for the correction of deformity more delicately and perfectly than any inanimate object ever invented."[1] The proper manipulations and exercises for each form of talipes will be subsequently described.

Valuable adjuncts, especially in paralytic cases, are rubbing of the limbs, douching with hot and cold water, and the use of the constant current in preference to the interrupted or Faradic.

3. *Operation.*—In the majority of club-feet some form of operation is required, either tenotomy, fasciotomy, forcible manipulation, wrenching, tarsotomy, or tarsectomy.

Wolff's Law.—Wolff's law states that—

"Every change in the form and position of the bones, or of their function, is followed by certain definite changes in their internal architecture, and equally definite secondary alterations of their external conformation in accordance with mathematical laws."

To put the matter quite concisely, the external shape of the bone is the result of functional adaptation. Wolff has demonstrated the truth of this law in cases of fracture and dislocation, not only in modifications at the site of injury, but in the uninjured regions far removed therefrom. Analogous results follow changes of position due to diseases of bones and joints. The bone is strengthened and thickened at those points where most stress and pressure come upon it, and is weakened at the opposite points.

[1] *New York Med. Jour.*, 4th March 1895, p. 387.

This is a marked contrast with the Volkmann-Hueter theory, which says that atrophy occurs on the concave side of a deformed bone. We now know that such is not the case from observation of museum specimens, which show bony condensation of the spongiosa, and thickening of the compact shell on the concave side of the curve.

Wolff, in support of his theory, has cited genu valgum, habitual scoliosis: with the production of wedge-shaped vertebræ; and the transformation of the bony structures of the foot. Such transformations have the object of enabling the bones in their altered positions and relationships to meet the new and abnormally directed stress thrown upon them. Deformity is no more to be regarded as a disease formation than is hypertrophy of the heart in a case of valvular insufficiency. Deformity, in fact, is that shape of the bones which, as in normal conditions, permits the greatest possible weight to be borne upon the least amount of normal material, allows the bones to functionate as organs of support, and enables them to withstand weight-pressure and the tension of the muscles without collapsing. When conditions exist which lie outside the skeleton, adaptive transformation of the inner structure and outer shape of the bones takes place according to the altered demands. Recognition and full appreciation of these important conclusions of Wolff constitute the foundation of the treatment of deformities of all kinds.

CHAPTER VIII

CONGENITAL CLUB-FOOT

Varieties—Statistics—Congenital Talipes Equino-varus—Degrees—Anatomy—Ætiology and Causation—Prognosis—Diagnosis.

Varieties.—The varieties met with are talipes equino-varus, by far the most frequent; then in order of occurrence: T. valgus, varus, calcaneo-valgus, equinus, calcaneus, equino-valgus, calcaneo-varus.

Whitman[1] gives some very interesting statistics of the occurrence of congenital and acquired talipes, and the frequency of the varieties. No less than 4718 cases of talipes seen at the Hospital for the Ruptured and Crippled, New York, were analysed by Drs. Townsend, Waller and Weingarten. Of these, 2103 were congenital and 2615 were acquired. Of the congenital cases, 1355 were in males and 748 in females; of the acquired, 1416 were in males and 1199 in females. In each variety the right foot is more often affected than the left; and in congenital talipes the deformity is nearly as often of both as of one foot, while in the acquired, unilateral deformity is more common.

THE RELATIVE FREQUENCY OF THE DIFFERENT FORMS OF CONGENITAL TALIPES.

	Cases.	Percentage.
Equino-varus	1629	77·4
Valgus	144	6·8
Varus	89	4·2
Calcaneo-valgus	87	4·1
Equinus	49	2·3
Calcaneus	47	2·2
Equino-valgus	35	1·6
Calcaneo-varus	10	
Cavus	5	
Valgo-cavus	1	
Equino-cavus	1	
Different deformity in each foot	54	

[1] *Orth. Surg.* 3rd ed. p. 760.

The author's statistics of 773 cases of talipes coming under his care, of which 311 were congenital, are:—

	Congenital.	Paralytic.	Other Causes.	Total.
T. equino-varus .	211	102	5	318
„ equinus . .	14	89	17	120
„ varus . .	44	27	...	71
„ valgus . .	11	50	5	66
„ plantaris . .	...	55	2	57
„ calcaneo-valgus .	21	31	...	52
„ arcuatus . .	...	37	...	37
„ calcaneus . .	6	25	...	31
„ equino-valgus .	2	15	...	17
„ calcaneo-varus .	2	2	...	4
	311	433	29	773

By a widely spread but illogical custom, congenital talipes equino-varus is held to be synonymous with congenital club-foot, thereby ignoring the occurrence of the rarer varieties of congenital displacement of the foot. We shall have occasion to speak of each form in its place, but for the immediate present we deal with

CONGENITAL TALIPES EQUINO-VARUS (CLUB-FOOT)

The Nature of the Deformity is as follows:—

1. The heel is raised and the foot is extended, *i.e.* in a position of plantar flexion.

2. The sole of the foot is adducted and brought toward the middle line instead of being directed to the front. It is also inverted.

3. The internal border of the foot is raised to a varying degree, shortened and bent upon itself, so that it is concave. The adduction of the great toe is often very marked, the first inter-digital space being wide, and the great toe is somewhat flexed, while the small toes are extended. In some cases the great toe appears to be partly capable of opposing itself to the other toes. This may be an approach to a reversion in type to the Quadrumana.[1] The incurvation of the great toe is a distinct clinical feature of these cases, and

[1] For a perfect example of "opposing" power in the great toes, see a remarkable case by the author, *Lancet*, 17th Feb. 1894.

gives a pigeon-toed appearance to the foot when the deformity of other parts is cured.

4. The external border of the foot is convex. When in contact with the ground, it forms the main point of support in progression.

The deformity is compound, and its elements are grouped around two places:—

A. In the foot, chiefly in the neighbourhood of the medio-tarsal joint, and to a less degree at the tarso-metatarsal and metatarso-phalangeal articulations.

B. At the ankle.

Recognition of these points is essential to proper treatment. The back part of the foot, *i.e.*, behind the medio-tarsal joint, must serve as a fixed point for the correction of the front part. And fixation of the back part can only be obtained by leaving the tendo Achillis intact until the front part is restored.

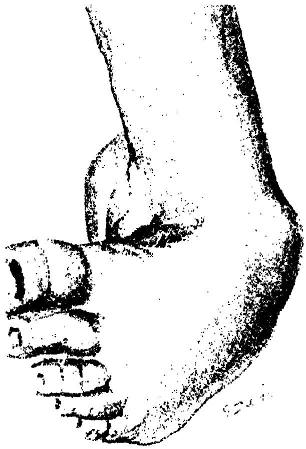


FIG. 166.—Untreated Congenital Talipes Equino-Varus in a child, aged 2 years. The elevation and shortening of the heel are shown.

Some cases show a curious rotation of the front part of the foot. Instead of the anterior portion being rotated so that its inner border is raised and forms part of the same curve as that of the posterior part, it is twisted upon the os calcis and astragalus at the medio-tarsal joint, and is rotated so that the inner border comes to the ground at the same time as the outer, or even sooner. Many of these cases of double twist in the foot have the much-separated big toe already spoken of, and no doubt the partial power of opposition of the first digit to the remaining toes explains the twist. The chief interest lies in the difficulty of entirely overcoming the deformity, and obtaining a shapely foot by treatment.

Frequency of Congenital Equino-Varus.—Bessel-Hagen[1] noted 15 congenital deformities of the feet in 13,668 births at full time in the Charité Hospital at Berlin. Of these 15, 10 were varus or equino-varus, 2 were valgus, 1 was calcaneo-valgus; in one case there was varus of one foot and calcaneo-valgus of the other; in the

[1] *Über die Pathol. des Klumpfusses*, etc., *Verhandl. d. deutscher Ges. f. Chir.*, 1885, and *Die Pathol. und Therapie.* Petters, Heidelberg, 1889.

remaining case varus of one foot and valgus of the other existed. Of 6969 patients with deformities seen at the Children's Hospital, Boston, there were 488 cases of "club-foot."[1] Congenital club-foot is more frequent in boys than girls. Of 147 cases, Heine reckoned 97 boys and 50 girls; and of 245 cases of Bessel-Hagen, 156 were boys and 89 girls.[2]

Double congenital varus is more usual than single. In the latter event, the deformity is more often on the right side than the left. Frequently, with club-foot of congenital origin, meningocele, spina bifida, partial or complete amputation of the limbs, absence

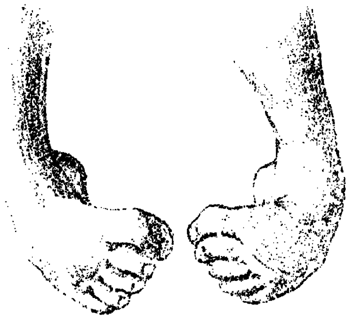


FIG. 167.—Congenital Talipes Equino-Varus of a severe degree, in an infant aged 7 weeks. The deformity is more marked in the left than in the right foot.

FIG. 168.—Back view of Fig. 167. In the left foot the transverse crease in the sole of the foot is well marked.

of fingers, polydactylism, syndactylism, and absence of some of the bones of the leg or foot, are found to co-exist.[3]

Appearances of Congenital Equino-Varus in the Infant.—1. The heel is elevated, and cannot be brought to the ground with the knee extended.

[1] Bradford and Lovett, *Orth. Surg.*, 3rd edition, p. 518.

[2] Cf. W. R. Townshend, "A Statistical Paper on Club-Foot," *Trans. Med. Soc.*, New York, 1890, and supplemented by Drs. Waller and Weingarten for Royal Whitman, *Orth. Surg.* 3rd edition, p. 760. Statistics are given of 4718 cases of talipes, 2103 being congenital and 2615 acquired. These pages in Whitman's book are well worthy of perusal.

[3] An analysis of 151 of my own cases of congenital equino-varus gives the following results: boys 108, girls 43, both feet affected 76, right foot alone 39, left foot alone 22. In one case equino-varus of the right foot and equinus of the left, in another, calcaneo-valgus of the left and equino-varus of the right, co-existed. In one instance the index and third fingers of the right hand were crossed and united, in another hydrocephalus, in a third congenital hydrocele, and in two others spina bifida, and in one a congenital sacral tumour were present.

2. The foot is adducted and rotated so that the dorsum looks outward, forward, and downward, and the sole upward, backward, and inward.

3. The inner border is raised and more or less approximated to the leg, and is also concave. The outer border is convex, and when the foot is brought to the ground it alone is in contact.

4. The affected foot is sometimes smaller than its fellow on account of the delayed development of the limb.

5. The heel is small.

6. The internal malleolus is buried and lost in the concavity which the inner border of the foot makes with the leg, while the external is more prominent than normal.

7. In thin children the dorsum of the foot is irregular, owing to the displacement of the head of the astragalus and the prominence of the anterior extremity of the os calcis.

Degrees.—The deformity varies according to age. 1. In slight cases the foot can be manually corrected. It is, however, well to remember that normal infants, who have not commenced to walk, usually hold the foot in a position of slight varus.

2. In the second degree the foot cannot be replaced passively. On attempting forcible reposition there remains some adduction or extension of the foot, and the sole cannot be planted squarely on the ground; the great toe also is much separated from the second. In the latter case the peculiar external rotation of the foot (the doubly twisted foot) mentioned above is often seen.

3. In the third degree, which is seen in children and adults, the foot is in a rigid and resistant state, with strong contraction of the soft parts.

4. In the fourth degree the deformity is inveterate and of old standing, and much malposition of the bones is present.

Appearances of Congenital Equino-Varus in Childhood.—When the child first places its foot on the ground in walking, if a slight degree of varus exist, the weight of the body is sufficient to overcome it. If more than the first degree is present, then the weight of the body accentuates the deformity, and the following effects are observed as the patient grows older:—

The internal border of the foot looks directly upward, the weight of the body is borne on the external border and, in severe cases, on the dorsum. The sole looks directly inward and often upward, and the dorsum downward and outward. The plantar fascia, the tibiales, and the tendo Achillis are felt to be firmly contracted.

The heel is considerably raised, small, and pointed, and covered by thin and tender skin. Two creases are seen in the sole of the foot, one transversely opposite the medio-tarsal joint, and the

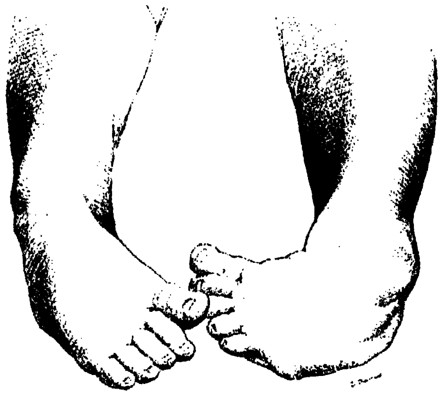


FIG. 169.—Congenital Talipes Equino-Varus in an infant aged 3 months.

other longitudinal, starting posteriorly from near the mid-point of the transverse fold, and running to the first interdigital cleft. Adams says[1] that "the presence of these creases is at once

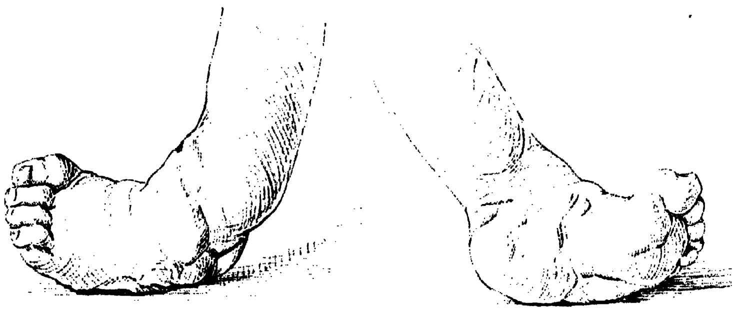


FIG. 170.—Appearances presented by untreated Congenital Talipes Equino-Varus in a woman aged 39 years. The transverse and longitudinal groovings in the foot are seen.

diagnostic of the congenital nature of the affection, and may with certainty be relied upon."

The skin of the external border and dorsum is thickened and studded with corns, which inflame and suppurate from time to time, and render locomotion temporarily impossible. Between the

[1] *Club-Foot*, 2nd edition, p. 144.

skin and the bones bursæ form, which are also liable to inflammation. The foot is always shorter and smaller than its fellow. In this tardy development the leg shares, and a shortening of 1 inch in the limb is not unusual. The muscles are also smaller, although they may be as firm or firmer than in the unaffected limb. The "swell" of the calf is higher on the side of the deformity, so that the greatest measurement of the calf is nearer the knee-joint. Coldness and blueness of the limb are absent.

The name "reel-foot" or "reel-feet" expresses the character of the gait when both feet are deformed. In walking, one foot must be lifted over the other and the patient waddles. This may be a cause of that distortion of the head and neck of the femur, which undoubtedly exists in these cases. From time to time the feet become very painful, and the patient has to lie up. But with boots made to the shape of the feet much activity is possible, and older patients often prefer to continue to walk with the deformity, rather than undergo the drastic procedure of tarsectomy frequently advised by surgeons. Indeed, Mr. Keetley stated[1] that a patient, whom he was called to attend for some other cause, and who was affected with double congenital club-feet, one of which had been tarsectomised, was far better pleased with the deformed foot for purposes of locomotion than he was with the foot which had been operated on. In the patient's opinion, the elastic deformed foot was more helpful than the rigid, although well-shaped tarsectomised foot.

FIG. 171.—Tracing of the Sole of the left foot from a case of Congenital Talipes Equino-Varus, associated with Spina Bifida.

An impression of the outline of the sole taken upon brown paper with printers' ink will reveal the adduction of the foot, and give evidence of the extent to which the sole touches the ground (Fig. 171). The corns and bursæ which form have already been alluded to. In some cases the suppuration and ulceration arising from them is so severe that amputation has been done.

Anatomy.—The observations of Little,[2] Adams,[3] Parker, and Shattock[4] in this country, of Nélaton[5] and Rochard[6] in France,

[1] *Brit. Orth. Soc. Trans.*, 31st Jan. 1895.
[2] *On Deformities*, 1853.
[3] *Club-Foot*, 2nd edition, 1873.
[4] *Congenital Club-Foot*, 1887.
[5] *Arch. générales de méd.*, April 1891.
[6] *Revue d'orthopédie*, 1st Sept. 1891.

of Bessel-Hagen[1] and Volkmann[2] in Germany, of Hartley[3] and others in America, have rendered us conversant with the anatomy of congenital equino-varus. A thorough description has been furnished us by Messrs. Walsham and Hughes in their work on *Deformities of the Foot.* For full details reference should be made to the originals. I wish to draw attention to the following points. The deformity affects the whole foot and is not confined to any one part. The *astragalus* shows very marked changes. It is extended at the ankle-joint, and is subluxated forward, so that only the posterior part of the upper articular surface enters into the joint. The anterior portion of this surface lies in front of the joint, and it is often so broad, that the mortise of the tibia and fibula is altogether too small to receive it. This fact becomes of great importance clinically, for it explains the great difficulty, often experienced in treatment, of securing sufficient dorsi-flexion at the ankle. It is a frequent cause of relapse and will be alluded to later. The head and neck of the astragalus are twisted inwards, the angle of the neck being increased from 10° to as much as 53°. On the outer side of the head and neck there is frequently seen a large abnormal bony prominence, the prefibular tubercle (Fig. 172, B), which grows up in front of the tibio-fibular joint, and effectually prevents reduction of the partially extruded astragalus into the ankle-joint. As the astragalus is twisted inwards, the relationship of its articular surfaces to its neighbours is modified accordingly. In old-standing deformity, the shape and outline of the bone is so altered that it is sometimes difficult to define the articulations. This is partly due to the formation of the prefibular tubercle, which is prominent on the outer side of the dorsum of the foot.

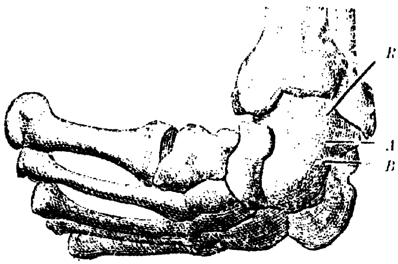


FIG. 172.—Skeleton of part of a Foot affected with Inveterate Congenital Talipes Equino-Varus (Musée Dupuytren: after Rédard). *A*, abnormal quadrilateral surface on outer aspect of the astragalus. *B*, Pre-fibular-tubercle. *R*, Bony ridge on the astragalus which locks against the tibia and prevents reduction.

But, more often the changes are caused by the formation of a

[1] "Die Path. des Klumpfusses," *Verhand. d. deutsch. Ges. f. Chir.*, 1885.
[2] "Zur Ätiologie der Klumpfüsse," *Deutsch. Klinik*, Berlin, 1863.
[3] *N.Y. Med. Rec.*, 18th Aug. 1894.

new non-articular surface on the astragalus (Figs. 206-210, A), which the author believes has not hitherto been described or figured. The surface is nearly quadrilateral, its upper and inner border is coterminous with the outer part of the anterior and lower border of the tibia (Fig. 213, R). The upper and outer border corresponds with the anterior edge of the external malleolus. The outer border blends with the prefibular tubercle already mentioned, and the inner part passes gradually into the neck and head of the astragalus. My friend and colleague, Mr. Rock Carling, has kindly drawn the Figs. 206 to 209, p. 269, from cases in which astragalectomy was necessary. This quadrilateral surface is often so placed that until the ligaments are divided, it appears to be a continuation of the tibia anteriorly downward and outward.

The Os calcis.—Its posterior part is elevated, and the whole bone, instead of being nearly horizontal, is so placed that its long axis is directed downward, forward, and inward. The tuberosities are feebly developed, and so is the sustentaculum tali. In almost all club-feet the bone is twisted round its long axis, so that its inner surface looks more upward, and its outer surface more downward than normal. This often constitutes a residual deformity, after treatment. It gives an unsightly appearance to the foot, and calls for special attention.

The Cuboid is displaced inwards, following the os calcis, and becomes more quadrilateral in shape, particularly on its external aspect.

The Scaphoid is drawn upward and inward, and is often in contact with and articulates with the internal malleolus. In adult life it is much atrophied. The cuneiform and metatarsal bones follow the changes in direction of the foot, but undergo comparatively little alteration in shape. The tibia and fibula are rotated inwards on their long axes, it may be through an arc of 45°. Sometimes the rotation exists in a less degree in the femur.

The Ligaments.—Those on the dorsum and external border of the foot are elongated, and those on the sole and internal border are contracted, particularly the anterior part of the internal lateral ligament of the ankle, and the astragalo-scaphoid and inferior calcaneo-scaphoid ligaments. The posterior ligament of the ankle also undergoes adaptive shortening.

Muscles and Fasciæ.—Displacement inward of the tibialis anticus, extensor communis digitorum, and extensor proprius pollicis tendons, is well marked. These muscles and the tibialis posticus are shortened, and their tendons are too tense. The tendo Achillis is

almost always too far inward, and assists in the inversion of the sole. The plantar fascia, especially its inner border, is much shortened and sometimes thickened. Such then, briefly, are the conditions; and it is evident that all the component parts of the foot participate in the deformity, and frequently the whole lower limb is affected. Thus we may meet with excessive inward rotation of the bones of the limb, looseness of the ligaments of the knee-joints, and incurvation of the neck of the femur.

The Ætiology and Causation of Congenital Club-Foot.—The most convincing treatise on this subject is that by Julius Wolff.[1] He has approached the subject in a scientific spirit, and exhibits in his writings the widest grasp of the whole matter. He discusses thoroughly all the theories advanced up to that date (1903).

The practical value of his remarks is that his conclusions have led him to treat club-foot, whether congenital or acquired, on rational methods. It is not necessary to repeat what has been written already on Wolff's law, but he says "the deformities of club-foot are such as will best enable the bones in their altered positions to meet the new and abnormally directed stresses and strains thrown upon them." If, by treatment, a foot can be fixed for a sufficient time in the fully-corrected position, and if weight can be brought to bear upon it in this position, the soft parts and even the bones become transformed, and will adapt themselves in such a way as to effect a cure.

Performance of function in a wrong position leads to deformity, but if the foot is put into the right position normal function induces normal structure and shape. Tempting as it may be to discuss the various theories which have been advanced, we can only glance at them. For full information on these points the reader is referred to Julius Wolff's work. In those instances of congenital club-foot where there is partial or entire deficiency of the tibia or fibula, and in those due to congenital paralytic conditions associated with spina bifida, there is no doubt as to the causation. Some of the views on ætiology are the following:—

(1) That club-foot is due to prolonged retention in the deformed position *in utero*. But club-foot has been found in extra-uterine fœtation, and in a ruptured tubal gestation. This is the view of the great majority of surgeons who look on the typical club-foot as originally a normal foot, which has later on, by some external force, been converted into a deformed one.

[1] *Club-Foot, its Causes, Nature, and Treatment*, Berlin, 1903.

Pressure of the uterine walls and deficiency of liquor amnii have been cited as causes, and Volkmann has drawn attention to the marks on the dorsum of one foot arising from the pressure of the other. In Volkmann's cases the pressure marks were seen mostly in calcaneo-valgus, and not in the much more common deformity of equino-varus. Wolff himself had never seen a sign of pressure on the dorsum of a congenital equino-varus which he could with certainty identify as a Volkmann's pressure mark.

With regard to deficiency of liquor amnii, at the birth of many club-footed children the liquor amnii is in excess. Messrs. Parker and Shattock have in this country been the strongest advocates of the pressure-theory and of the adaptation of the parts to their surroundings. Their views appear to have some support in those cases of locking of the feet, where equino-varus occurs on one side and calcaneo-valgus on the other. The question arises whether in the cases cited there was any other evidence on the body of uterine compression. For it is not possible to imagine that the uterine wall was contracted at one spot only so as to produce club-foot. We should also like to know if the liquor amnii was deficient. If it be granted, on the other hand, that club-foot arises from an error of the embryonic rudiment, it must exist long before any cramping of the fœtus can occur.

(2) Another theory which has been advanced is the muscular one, that club-foot is due to contraction of some groups of muscles and loss of power in others, owing to nervous diseases *in utero*, but there is no evidence of any nerve abnormality, except when spina bifida is present.

(3) Meckel, St-Hilaire, Hueter, and Adams thought that malformation depended upon arrest of development of the foot and arrested rotation in the leg. Such may be the case, but if so, what are the causes? It is simple to talk of reversion in type, but this does not carry us very far. If a reversion of type, to which type, and why to a particular type?

(4) Wolff believes that neither the cramped position of the foot nor the so-called pressure marks can be taken as special signs of secondary club-foot, meaning by the word "secondary" that the feet were originally in normal position, and have become distorted *in utero*. A sign in support of the pressure theory which would have the greatest value in settling the matter would be the existence of other pressure marks, *e.g.*, on the head and gluteal region, and co-existing with club-foot. These have not yet been seen. Why

then should the foot be picked out and held fast? And why, when the fœtal movements are so lively, should the foot not have the strength to free itself from incarceration, unless the uterus at that particular spot has become as rigid as iron? In spite of this it is still regarded as an irrefragable dogma that the typical club-foot was originally of normal form, but this view is merely conjectural.

(5) We are then driven to the assumption that in some cases club-foot is an expression of a developmental error, and this is supported by the late W. J. Little's observations on transmission in some families of club-foot through the *male* side only. It is, in fact, a primary error in the direction of the development of the foot portion of the early embryo.

From a practical point of view we must realise that the abnormal change concerns the whole foot, and not any one bone. The deformity is as if produced at a single casting of the foot, without one characteristic being primary and another secondary. Whether the typical club-foot is to be traced back to the very beginning of embryonic life, or to a later developmental stage, does not affect in the least the fact that only in very infrequent and atypical cases does club-foot arise secondarily from mechanical pressure.

However, in examples of club-foot a mechanical method of origin is so forced upon us that it would be a violation of actual fact to question it.

To sum up: (1) A small proportion of cases are due to deficiency of one of the bones of the leg. (2) A few are dependent upon nerve lesions, cerebral or spinal, especially spina bifida. (3) The causation of many is not absolutely settled by the data at our command. (4) Parker[1] states, "the most common modes of mechanical production are, (*a*) Accidental locking of parts; (*b*) Locking of parts due to abnormal position of the limbs; (*c*) Exceptional position of the limbs independently of locking; (*d*) Uterine environment from actual or relative deficiency of the liquor amnii."

The Prognosis of Congenital Equino-Varus.—The points in any given case upon which information will be sought are the following:—

1. Can a perfect foot be obtained?
2. Will a shapely foot result from treatment?

[1] *Congenital Club-Foot*, pp. 32, 33.

3. Will the patient be able to walk comfortably and rapidly?

4. What possibility is there of relapse, and if relapse occur, can the foot again be rectified?

5. The duration of time during which treatment is necessary?

1. *Can a perfect Foot be obtained?*—The answer to the question depends upon—

(*a*) The age at which treatment is begun and the degree of deformity. It is quite certain that many cases of congenital equino-varus of the first and second degrees are cured if treatment is begun before walking is attempted. At this tender age the bones are largely cartilaginous, the ligaments are elastic, and the muscles are not structurally much shortened, therefore there is every prospect of successful treatment. The time when treatment should be instituted will be more particularly dwelt on in the chapter on the practical details of that branch of the subject. It is sufficient here to say that the earlier it is begun the more hopeful is the prognosis. Cases of the third degree, especially after weight has been borne on the deformed feet, seldom give perfect results so far as form is concerned, but the functional results are often all that can be desired.

(*b*) The amount of rigidity present. If rigidity is due to contraction of muscles, tendon, and fasciæ, much improvement will be obtained; but, naturally, the greater the rigidity the longer will be the duration of treatment. If rigidity is due to altered shape of articulations, although the foot may become useful for progression, yet the shape is rarely ideal.

(*c*) The presence of other deformities, *e.g.* genu recurvatum, undue laxity of the ligaments of the knee, excessive rotation of the tibia, fibula, and femur, complicates matters. The first two will yield to appropriate measures, and for the last osteotomy is an adequate remedy.

(*d*) Persistence in treatment. There can be no doubt that many cases of club-foot are cured for a time, and that, owing to want of due care, or to negligence on the part of parents, relapse takes place. It happens not unfrequently that a child leaves the hospital well able to walk, and the immediate result is all one could wish for. The parents are enjoined to bring the child up for observation every three months. Instead of doing so, they fail to attend for two or three years, and then come with the naïve remark that "the foot is going back."

It is the duty of the surgeon to insist that relapse, especially of congenital talipes, is a likely event so long as growth is going on, and every care must be taken to prevent it. The occasional want of this caution, but still more the negligence of the parents in not giving due heed to it, bring discredit at times, and too often unjustly, on the treatment of club-foot.

2. *Will a shapely Foot result from Treatment?*—In slighter degrees of varus the answer may be given in the affirmative. But in severer instances there will always remain the "square-toed" appearance, and the foot is ungainly. Still, so long as it is useful this unsightliness is not of primary importance.

3. *Will the Patient be able to Walk rapidly and comfortably?*—Again the question of degree must be a dominant factor. And it may be generally said that the less the bony framework is interfered with by excision and such drastic measures the more elastic will the foot remain. It follows that the less cicatricial tissue there is about the foot after treatment the less the distortion will be likely to recur. Even if the case relapses, better results can be obtained than if the parts have been badly mutilated by any severe procedure.

Reference has already been made to the case of a man with one tarsectomised foot and one untreated deformed foot, who much preferred the deformed to the tarsectomised foot because of its greater elasticity.

4. *What Possibility is there of Relapse? If the relapse occurs, can the foot be afterwards rectified?*—There is every likelihood of relapse in congenital cases unless persistent care is exercised all through childhood. Relapsed varus, however, can be cured.

5. *The Duration of Time required for Treatment.*—This must depend much on the degree of the deformity and the method adopted. A deformity of moderate severity can be removed by manipulation and wrenching in from a few weeks to a month. Active treatment is necessary only for weeks, care for years.

The Diagnosis of Congenital Equino-Varus.—In early childhood there will be no difficulty in distinguishing congenital from paralytic varus. The history of distortion of the feet from birth, the absence of much wasting of the muscles, the effective circulation in the limb, and the presence of the longitudinal and transverse furrows in the sole, will serve to prevent a congenital from being confused with a paralytic equino-varus. If spina bifida, or deficiency of one of the bones of the leg, or syndactylism be present, then a

case which may be presented to us is certainly one of congenital origin.

In later life, when the muscles are wasted, some difficulty may arise, but attention to the points in the subjoined table will be of much assistance.

Diagnostic points of congenital and paralytic equino-varus in the adult:—

	Congenital.	*Paralytic.*
History . . .	Affection has existed from birth.	Affection first noticed during second year or later, and preceded or accompanied by measles, and has been ushered in by convulsions.
Feet affected .	More often both .	More often one.
Circulation .	Good . . .	Feeble. Limb is cold, blue, and clammy.
Wasting of muscles	Little marked . .	Often well marked.
Electrical reactions	Present or slightly diminished in wasted muscles.	Reaction of degeneration.
Deficiency in growth of bones.	Not very evident .	Much shortening of leg and foot.
Furrows in sole .	Present . . .	Absent.
Prominences on dorsum of foot.	Several, and general outline is irregular.	Head of astragalus is prominent, but general outline is rounded.

From spastic paralysis the diagnosis of congenital equino-varus is more difficult. The presence of rigidity of the knees, adduction of the thighs, flexion of the forearms, and contraction of the hands are points sufficiently distinctive of spastic paralysis. The hysterical form of equino-varus readily disappears under an anaesthetic.

CHAPTER IX

CONGENITAL CLUB-FOOT—(*Continued*)

Treatment of Congenital Equino-Varus—Obstacles to Reduction—Treatment of Infantile, Relapsed, and Neglected Forms by Manipulation, Wrenching, and Operation—Tenotomy—Operations on Bones—Other Forms of Congenital Club-Foot.

Treatment of Congenital Equino-Varus

The deformity in club-foot is due to development of the part in wrong directions. The abnormality affects not only the foot, but the leg as well. It therefore follows that the direction of the growing lines must be changed and altered to the normal, and this new direction of growth fostered until no signs of relapse are evident. Club-foot is a deformity which is entirely curable, but its treatment is tedious because of the lengthened supervision required on the part of the surgeon until all possibility of relapse ceases to exist. There is probably no other deformity which shows so many instances of incomplete and imperfect treatment. It is often difficult to apportion the blame, and we cannot help thinking that in some cases the surgeon is directly responsible. He does not insist upon the lengthened supervision, so essential in these cases after the foot has been replaced. Active treatment may extend over a few weeks or months; supervision must be carried on for years. In club-foot, half-cures are no cures at all, and relapse is inevitable in partially-cured cases.

The Obstacles to Reduction in Congenital Talipes Equino-Varus.—I. In the infant, obstacles arise mainly in the internal lateral ligament of the ankle, the plantar ligaments and fascia, the tendons of the tibialis posticus and anticus and the tendo Achillis, the astragalo-scaphoid and calcaneo-scaphoid ligaments, and, lastly, from the malformation of the astragalus and other bones. At the age we are speaking of, these obstacles may be overcome by

tenotomy, fasciotomy, division of the ligaments, manipulation, and patience.

II. In the adult the chief difficulties arise: (1) From the abnormal shape of the bones, especially the downward and inward deflection of the neck of the astragalus; and in severe cases the fixed subluxation of the cuboid and scaphoid; (2) from the partial or entire obliteration of the old joints, and the difficulty of bringing the joint-surfaces into proper contact, as, for example, in the case of the ankle where the anterior part of the upper articular surface of the astragalus is much too broad to be pushed back between the malleoli, or a pre-fibular tubercle or the rough quadrilateral surface described by the author (pp. 232, 233) exists. These conditions act as grave hindrances to the reduction of the plantar flexion, and have led to the operation of astragalectomy; (3) from the formation of new joints; (4) from fixation of the ligaments and tendons in their abnormal attachments and course; and last, but not least, from the difficulty of bringing any pressure to bear on the skin of the foot, already tender from pressure, and now liable to sores; and in open operations, from the defective power of healing frequently seen in congenital club-foot.

On p. 229 we spoke of four degrees or classes of club-foot. The first degree comprises those cases in which the deformity is comparatively slight, and can be overcome by manipulation.

The second degree includes those in which the deformity cannot be entirely reduced, and, on attempting to do so the foot springs back into its original position.

These two classes are the forms found in *infantile* club-foot.

In the third degree the foot is in a rigid and resistant state, with strong contraction of the soft parts, and the amount of possible alteration in the position of the foot is very small.

In the fourth degree the deformity is inveterate and of old standing, and much malposition of the bones is present.

Classes 3 and 4 comprise the *relapsed* and *neglected* cases. We have therefore to deal with infantile and with neglected and relapsed club-foot.

What are the objects of treatment in congenital club-foot? They are (1) to bring the foot into its normal position, and (2) by suitable measures to keep it in that position and prevent any return of the deformity.

In every form of club-foot, treatment may be divided into three stages:—

1. The rectification of the deformity.
2. The maintenance of the foot in the rectified position while its internal structure is being transformed, and until the patient is able to keep it in its natural position—that is, until the muscles have acquired sufficient power to hold the foot in perfect balance.
3. The period of supervision. During this period all complicating deformities, such as the inward twist of the bones of the lower extremity, and looseness of the ligaments of the knee, are treated; and particular care is taken to see that the foot is carrying out its function normally.

So that, to put the matter briefly, the stages of treatment are rectification, support, and supervision.

To bring about the first, rectification, we have at our command the following methods:—

(*a*) Manipulation and various forms of splints and bandages.
(*b*) Operative measures, such as wrenching, either manual or instrumental, tenotomy, wide division of all the resistant structures, and operations on bones.
(*c*) Physiological methods, as massage and the application of electricity, passive movements, and more especially active movements. Every effort should be made to encourage the patient to practise those movements which bring into play the muscles on the anterior and external aspects of the leg. They, on account of the malposition of the foot, are often stretched and weakened, while their opponents, those on the posterior and inner aspects, are relatively hypertrophied.

It is useless to replace a foot unless the balance of the muscles is restored along these lines, and a cure can only be considered complete when the patient is able voluntarily to place the foot and maintain it in a position, which is the exact opposite to that of the original deformity.

With reference to the second object, support, the foot is held in its proper position until its bony and ligamentous structures become transformed to the normal. If it can be used during this stage, then we at once bring into play the principles of the adaptation of form to function so clearly enunciated by Julius Wolff; and the

great merit of his particular form of treatment is that he applies so successfully the law which goes by his name to club-foot.

As to the third object—supervision—particular attention is paid to footgear and to the manner of walking. Upon the thoroughness with which this stage is carried out depends more than upon anything else the ultimate success of the case.

Whatever means be used for rectifying the deformity, there is a central fact of great importance which is sometimes overlooked, namely, that congenital talipes equino-varus is a compound deformity. The varus portion of the deformity, although affecting the whole foot, has its maximum intensity at and about the medio-tarsal joint; the equinus part of the deformity is centralised at the ankle joint. In treatment we must recognise this fact. In order to reduce the varus there must be some fixed point from which to take purchase, and such a point already exists at the os calcis and astragalus, owing to the contracted tendo Achillis fixing these bones firmly in their relations to the bones of the leg. If the position of this fixed point is prematurely disturbed by section of the tendo Achillis, much of the leverage which can be exerted from that part on the front of the foot is lost. The foot can be rotated at the ankle and sub-astragaloid joints in such a way as to produce a fallacious impression of reduction of the varus, long before it is complete. *It is therefore strongly insisted upon that whatever form of treatment be adopted for equino-varus it should be carried out in two distinct stages:*—

1. *Complete reduction of the varus portion before dividing the tendo Achillis.*
2. *The reduction of the equinus;* and in no case should the tendo Achillis be divided until all in-turning of the foot has disappeared, or better still, until *the foot is seen to be over-corrected and in the valgus position.*

The importance of these remarks cannot, in the writer's opinion, be over-estimated, and those who have had the most experience are fully in agreement with him. Many of the relapses are due to the harmful practice of dividing all the contracted structures at one sitting. As a matter of experience, one of two results usually happens: either the varus is incompletely reduced, or the uniting band of the tendo Achillis becomes too long, so that a very troublesome form of calcaneus, with much concavity of the sole of the foot, results.

When should Treatment be commenced?—There is a curious

idea prevalent that no form of operative treatment is possible until several months after birth, and it is difficult to ascertain whence this idea arose. Manipulation should be begun immediately after birth, and tenotomy is a justifiable procedure at the end of the first fortnight provided the infant is in good health. It is an error to defer operation until the child commences to walk. Valuable time is lost, and the distorted bones are more firmly set in their false positions. The liability to interruption of treatment by infantile complaints is much less to be feared within the first few months than at a later period. And it is of the utmost advantage to complete the operative treatment of club-foot before the commencement of dentition, when children are generally fretful, and often are affected by malaise and illness. Therefore, treatment should be commenced in all cases at the earliest possible moment, and all delay avoided.

THE TREATMENT OF INFANTILE CLUB-FOOT

1. **Of the First Degree.**—The foot can be momentarily replaced by manipulation. We have therefore to carry out these manipu-

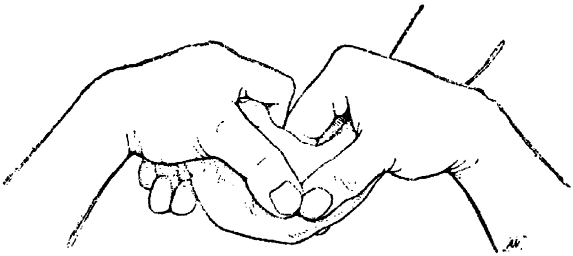


FIG. 173.—Treatment of Congenital Talipes Equino-Varus by Manipulation. Position of the Hands in overcoming the Inversion of the Foot (Berger and Banzet).

lations until the foot is over-corrected, and to maintain it in that position until the child is able to walk, and then complete the cure by putting the foot to its proper functional use.

Method of Manipulation.—The movements to be practised are (1) Abduction and eversion at the transverse tarsal and sub-astragaloid joints; (2) Flexion and extension of the whole foot at the ankle; (3) Finishing up with a movement of circumduction outwards, so that the foot is finally placed in a dorsiflexed and everted position (Figs. 173 - 175). Each movement is done

separately, and the foot is held in its final position for a few seconds, and then allowed to return momentarily to its original

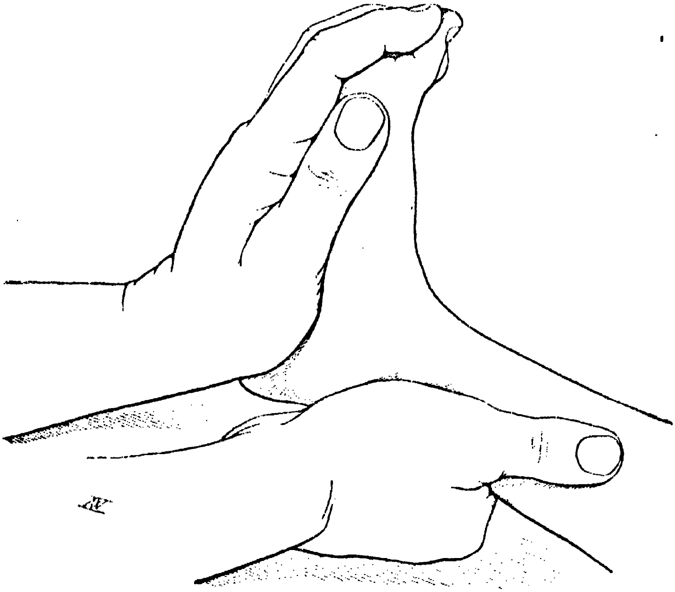


FIG. 174.—Manipulations to overcome the Equinus.

FIG. 175.—Position of the hands in overcoming the Inward Rotation of the sole of the foot in Congenital Talipes Equino-Varus (Berger and Banzet).

position. The time occupied at each *séance* should be ten to fifteen minutes, and the manipulations should be carried out thrice daily. The anterior tibial and peroneal groups of muscles must be massaged.

Mechanical Treatment.—In the intervals between the manipulations it is necessary to prevent the return of the foot to the deformed

FIG. 176.

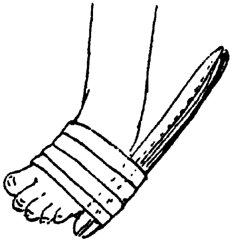


FIG. 177.

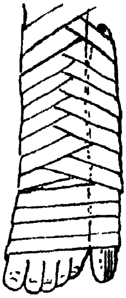


FIG. 178.

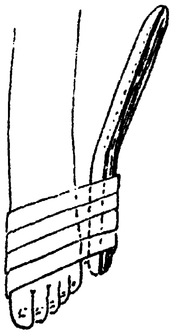


FIG. 179.

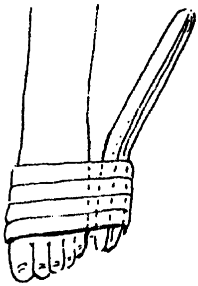


FIG. 180.

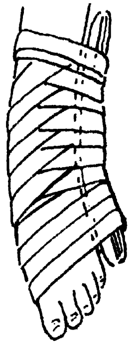


FIG. 181.

FIG. 176.—The Flexible Malleable Iron Splint padded and covered with macintosh.
FIG. 177.—The same fixed to the front part of the foot by a bandage.
FIG. 178.—The upper part of the splint has been brought into contact with the outer side of the leg, and by the leverage thus made, brings the Foot into a straight line with the leg, thus overcoming part of the Varus.
FIGS. 179, 180.—The splint is bent to a decreasing obtuse angle. It is secured to the front part of the foot.
FIG. 181.—Then by approximating the splint and the child's leg the foot is levered into the over-corrected position.

position and to maintain the correction so far as it has gone. This can be effected by:—

(1) A simple splint; or
(2) By the plaster bandage.

(1) The writer's preference is for the simple splint at this stage. There are several forms. The malleable iron splint used in this country (Fig. 176) is one of the best. It is a straight, well-padded

piece of soft iron, strong enough to neutralise the contracted muscles, and sufficiently flexible to be bent to any angle. It is applied as follows:—

The splint is first bent so as nearly to fit the outer border of the leg and foot (Fig. 177). It is then by three or four turns of a bandage fixed firmly to the foot, the upper part of the splint standing well away from the leg. Then the upper part is pushed inwards

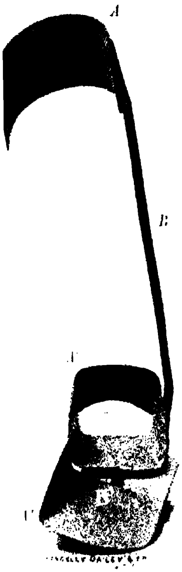


FIG. 182.

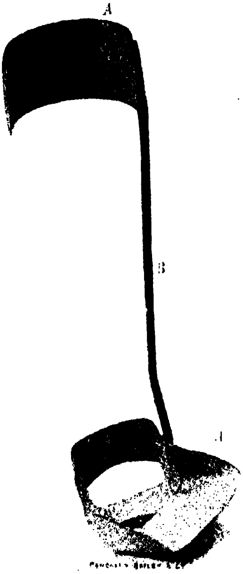


FIG. 183.

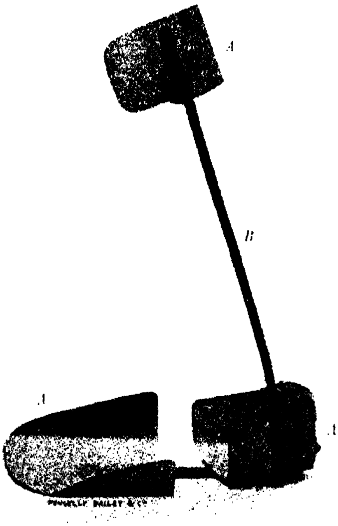


FIG. 184.

Simple Splint designed and used by the author for the Treatment of Talipes.

A, calf-band; *A′*, heel-piece; *A″*, retaining portion for front part of foot. *B*, flexible copper rod, ¼ inch in diameter; *B′*, another copper rod, opposite the medio-tarsal joint. The splint should be well padded before use. It is held in place by a bandage. The copper rod is on the outside of the leg for the treatment of Equino-Varus, and on the inside for Valgus. The splint is here shown as used for equino-varus.

FIG. 182.—The splint in the position of the deformed foot.

FIG. 183.—The splint having been applied in the position in Fig. 182, the copper rods *B*, *B′* are bent, so that the inversion and rotation of the foot are corrected.

FIG. 184.—The splint, shaped by bending of the copper rod *B*, so as to overcome the plantar flexion and inversion at the ankle.

until it touches the outer side of the leg, and therefore the lower part draws the foot out. The bandage is now carried upwards, and fixes the remaining part of the splint to the limb (Fig. 178). Gradually the angle of the splint is lessened or even reversed, until

the foot can not only be fixed in a straight line with the leg without pain, but is considerably abducted. The varus is thus entirely reduced (Figs. 179-181).

For the equinus the splint should be bent to a right angle, and fitted to the back of the leg or foot. But for this purpose the writer prefers the simple shoe (Figs. 182, 183, 184). It consists of a metal foot-piece, with a rim on the inner side to control the inner border of the foot. The foot-piece is connected by means of a soft copper rod passing upward on the outer side of the limb, with a band of sheet iron, which partially encircles the leg. The foot-piece and the soft copper rod can be bent or twisted to any angle desired. This shoe can be used from the first to remedy both the varus and the equinus. But it is not easy to retain it in position in small babies, and in them it is preferable to use the soft malleable iron splint to overcome the varus, and then, as the parts grow, to employ the shoe. In some cases a varus splint (Fig. 185) answers better, especially when it is necessary to control the knee.

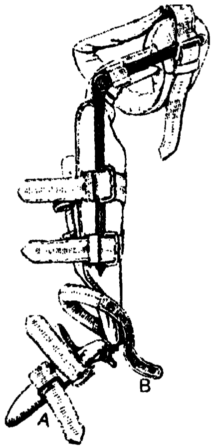


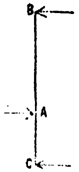
FIG. 185.—Adams's Varus Splint for the Treatment of Infantile Club-Foot after Tenotomy. At A, is a sole-strap, by which the front part of the foot can be abducted; at B, is a rack-and-pinion movement to overcome the plantar flexion at the ankle.

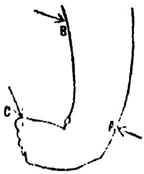
A few weeks of this treatment will place the foot in abduction and dorsiflexion, and it must be kept thus until the child begins to walk, when a walking apparatus, or—as it is designated in the United States of America—a retention brace is applied.

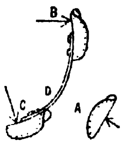
In that country the lever arrangement of the malleable iron splint has been utilised by Judson,[1] who describes his method as follows:—"The apparatus which I have conveniently used to effect the reduction before the child learns to stand is a simple retentive brace, which acts as a lever, making pressure on the outer side of the foot and ankle at A (Figs. 186-193), and counter-pressure at two points, one on the inner side of the leg at B, and the other at the inner border of the foot at C. The brace is made of sheet brass. Two curved discs, B and C (Figs. 188-190), are riveted to a shank (D), and thus is formed that part of the brace which supplies the points of counter-pressure, while on the other

[1] Quoted by Whitman, *Orth. Surg.* 3rd ed. pp. 773-775.

hand the point of pressure is brought into action by a third disc or shield (A), which is drawn tightly against the outer side of the foot and ankle, and held in its place by a strip of adhesive plaster (E), which includes the leg and the piece which connects the two discs (B and C). The discs are lined with two or three thicknesses of blanket. The brace is applied with three strips of adhesive plaster, the upper and lower pieces (F and G) are simply to keep the apparatus in place, while by drawing the middle strip (E) tightly over the shield, and straightening the brace from time to time, the







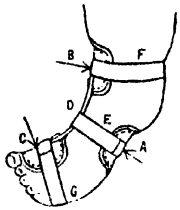
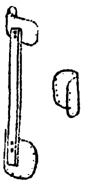
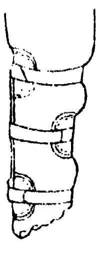


FIG. 186. FIG. 187. FIG. 188. FIG. 189.

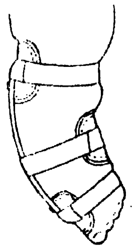


FIG. 190. FIG. 191. FIG. 192. FIG. 193.

The Judson Club-Foot Splint and its application. For explanation, see text.

deformity is gradually and gently reduced. At each re-application the brace is made a little straighter than the foot at that stage. This may readily be done by the hands, and then the adhesive strip (E) is to be tightened over the shield until the shape of the foot agrees with that of the brace. In a few days the brace is to be made still straighter, and again re-applied. It is to be removed every week or two weeks, and manipulation of the foot is of great importance. When the varus deformity is reduced, the equinus is gradually corrected by carrying the splint behind the internal malleolus; and, finally, if necessary, direct upward pressure may be applied by lengthening the brace, and applying it to the posterior aspect of the foot and leg."

(2) *Gradual Rectification of the Deformity by the Plaster Bandage.*—In young infants this method is not applicable, but after the first six months of life it is very useful. The drawbacks in infancy are the smallness of the parts, and the liability of the plaster to become sodden and dirty. There are also the disadvantages of frequent renewals, and plaster does not allow the necessary daily manipulations of the foot and the all-important massage of the weaker muscles. But there is one great advantage. The control of the case is in the hands of the surgeon, for it is only a very foolish parent who will remove the plaster. When splints are employed, the parents often neglect to apply them, or apply them wrongly.

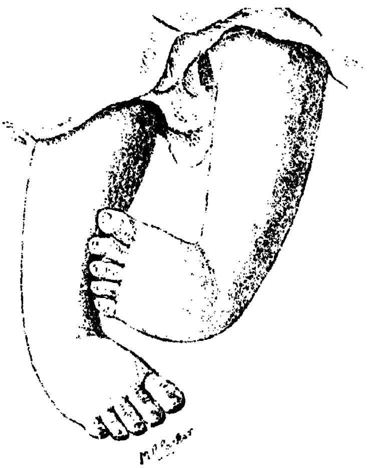


FIG. 194.—Congenital Talipes Equino-Varus of the First Degree in the Right, and of the Second Degree in the Left Foot, in an infant aged 5 weeks.

Considerable care must be taken to avoid irritating the skin or causing pressure sores, while the plaster bandage must at the same time fit closely. The varus deformity is usually first attacked, and then the equinus.

In applying the plaster, thin layers of cotton wool are placed between the toes; and to the outer aspect of the ankle, where the skin is thrown into folds, when the foot is straightened, vaseline should be applied. It is also advisable to protect the external malleolus with a rather thicker layer of cotton wool. A strip of adhesive plaster, long enough to reach from below the knee to two inches or more below the heel, is applied to the outer side of the leg, and the foot is now abducted and everted as far as it will go without discomfort. It is held in this attitude, and a narrow flannel bandage is applied to the limb, the turns being made from without downward and inward, so that its tension assists in retaining the foot in the new position. The lower part of the band of adhesive plaster, *i.e.* the part from the ankle downward, has not been included in the flannel bandage. A very light plaster bandage is now put on from the roots of the toes to the upper part of the leg in the same directions as the

flannel bandage. Into the lower folds of the plaster bandage the free part of the strip of adhesive plaster is incorporated, so that it assists in retaining the foot in its good position, and further prevents the plaster of Paris case from slipping off. When the plaster of Paris is dry, a long stocking of jacconet or macintosh is drawn over it and attached to the body clothing. This obviates the possibility of the child soiling the plaster. At the end of a week the bandage is removed, the leg and foot are gently bathed with spirit, dried and powdered, the foot further re-dressed, and a fresh bandage applied.

By correcting the foot at each successive application the deformity is reduced, and the part assumes a position of equino-valgus. And then the equinus is dealt with on the same lines. But the foot must not be merely forced upwards at the medio-tarsal joint. The heel itself must be drawn down by stretching the tendo Achillis, and therefore some force must be employed.

It is found more difficult to reduce the equinus than the varus. Still the foot ought to be over-corrected in three to four months after the commencement of the treatment, and should then be in a position of calcaneo-valgus. It can be retained thus until the child can walk in one of the simple supports to be described.

2. **Treatment of the Second Degree.**—The deformity in this degree is of this nature (Fig. 195):—

The foot cannot be fully everted nor brought into a straight line with the leg. The plantar fascia, the tendons of the tibialis anticus and posticus, the flexor longus pollicis, and perhaps that of the extensor proprius hallucis, are tense. Contraction of the tendo Achillis, and possibly of the posterior ligament of the ankle, also exist. In addition there is one frequent feature of bony deformity which must be taken fully into account, as it is a constant source of relapse. It is found in practice that despite section of the tendo Achillis and the posterior ligament of the ankle, it is impossible to dorsiflex the foot fully. This is due to displacement forwards of the astragalus, so that the widened anterior part of its articular surface cannot be made to enter the mortice of the ankle joint. In time the space between the malleoli becomes so small, and the width of the anterior part of the upper surface of the astragalus remains so great, that no ordinary manipulation will force it into its normal position. This matter will be dealt with later when we consider the question of relapsed club-foot. It is probably the most important cause

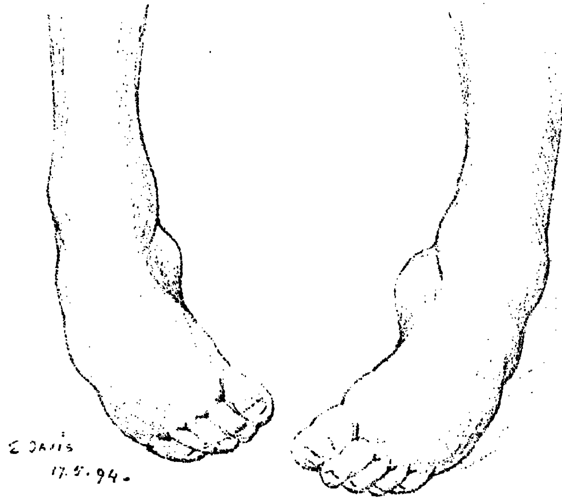


FIG. 195.—Congenital Talipes Equino-Varus of the Second Degree, before Treatment, in a child aged 4 years.

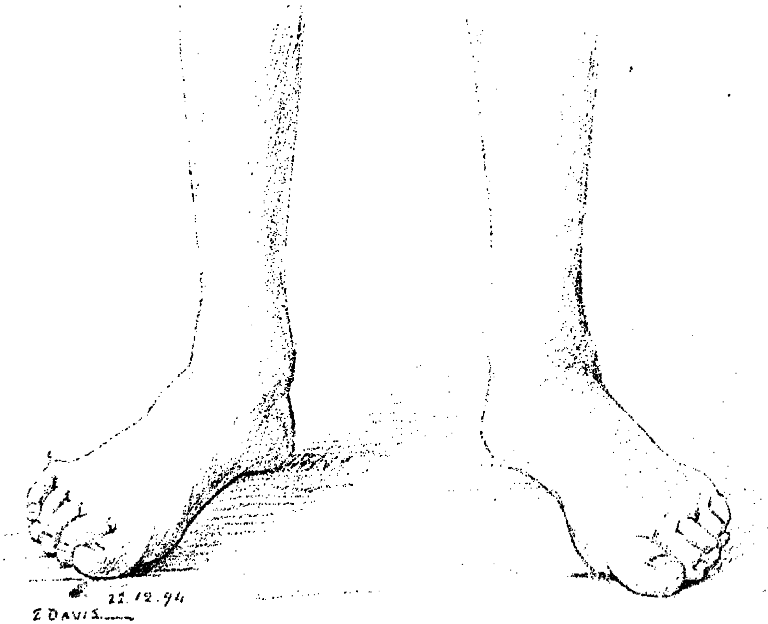


FIG. 196.—The same case after Treatment by Tenotomy, Manipulation, and Splints.

of failure in treating cases of the second degree. Not only is it impossible to bring the foot into a straight line with the leg, but also the foot cannot be dorsiflexed either to the right angle or beyond it.

Cases of the second degree may be treated by—

1. Tenotomy, with the subsequent use of shoes and walking apparatus.
2. Tenotomy, followed by wrenching on several occasions, and putting the foot in plaster of Paris after each partial correction.
3. By the methods of Lorenz and of Julius Wolff; although these, in the writer's opinion, are more adapted for cases of confirmed or neglected club-foot, and of relapsed club-foot, and will be discussed under those headings.

Cases of club-foot of the second degree also include "walking" cases, that is, cases in young children, where the patient has walked before the deformity has been corrected; and as examples of this form are usually found in children under four years of age, the bones of the limbs are still elastic and partly cartilaginous. Therefore it is not necessary to resort to severe operative procedures, meaning by this expression Phelps's operation or the various kinds of tarsectomy.

It is difficult to lay down rules or to dogmatise upon the procedure to be adopted. Some surgeons prefer tenotomy, accompanied or followed by wrenching or fixation; others prefer wrenching only. It is generally agreed that excision of bone is rarely called for in the treatment of this degree of club-foot, and indeed some writers express themselves in no measured terms upon this subject. Unduly emphatic expressions of opinion are quite unnecessary provided that the condition of the parts is fully understood.

We ourselves advocate tenotomy, fasciotomy, and section of the ligaments, succeeded by wrenching and fixation. We do not object in some cases to wrench the foot immediately after section of tendons, provided that we are assured that the operations have been carried out with due aseptic precautions. We think, however, that the performance of tenotomy saves time, and we regard a clean subcutaneous section as preferable to a so-called rectification by stretching of tendons and ligaments. The structures requiring division in talipes equino-varus of this degree are frequently the plantar fascia, and almost invariably the tibialis anticus and posticus

FIG. 197.—Double Congenital Talipes Equino-Varus, before Treatment, in an infant aged 6 weeks.

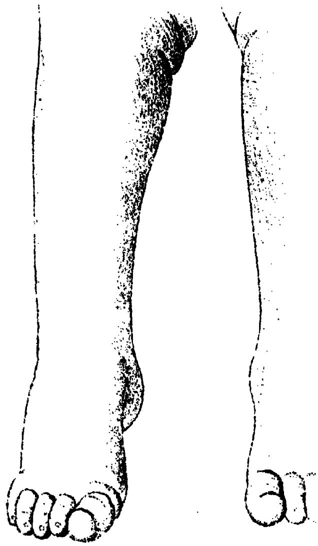


FIG. 198.—The Completion of the First
of Treatment, viz. the Reduction
Varus Deformity, leaving the Tendo A
intact, and the feet in the Equinus po

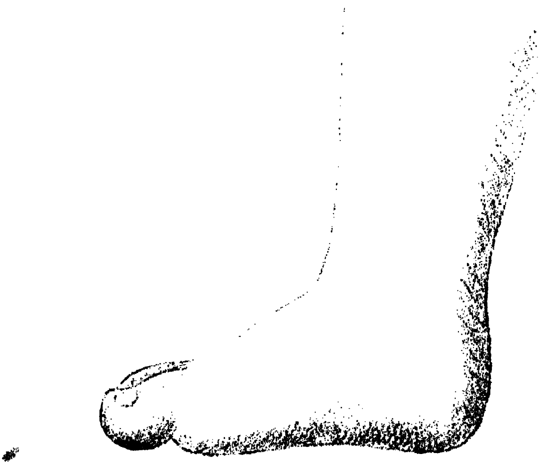


FIG. 199.—Completion of Treatment by section of the Tendo Achillis, and the position of the right foot at the age of 4 years.

the internal lateral ligament of the ankle joint, the superior and inferior astragalo-scaphoid, and the inferior calcaneo-scaphoid ligaments, the tendo Achillis, and the posterior ligament of the ankle-joint.

We here repeat that in our opinion it is absolutely disastrous to divide all these structures at once. The tendo Achillis and the posterior ligament of the ankle joint must be reserved as a second stage in the operative procedure, and section of them must not be attempted until the varus is over-corrected.

A short description of tenotomy is required, and in conjunction with it the description of the method of union of tendons in vol. i. p. 771 should be consulted. It is always well to bear in mind that while over-correction is desirable in some cases, in others the results may be deplorable, as for example in those instances where the tendo Achillis is allowed to become too long and an extremely troublesome form of talipes calcaneus results.

Fasciotomy; Tenotomy and Syndesmotomy or Section of the Ligaments

Tenotomes.—Formerly both blunt and sharp pointed tenotomy knives were used, but blunt ones are not necessary. Experience has shown that in all the tenotomies about the foot wounding of an artery or vein is of comparatively little importance. The cutting edge of a sharp tenotomy knife is slightly convex, and the point should correspond with the middle of the blade. Tenotomes should be strong at the neck, and the cutting edge keen. The back of the knife is strong and rounded, so as to afford sufficient resistance to a tough tendon (Fig. 200). Many tenotomes are too large and clumsy. A skilful surgeon always prefers to work with small rather than large knives. He relies more upon his sense of touch, as communicated through the instrument, than upon mere force and cutting power.

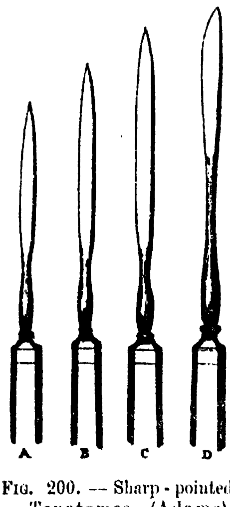


Fig. 200. — Sharp-pointed Tenotomes (Adams). Blunt-pointed Tenotomes are seldom used.

Anæsthetics in Tenotomy.—For all forms of tenotomy nitrous oxide gas is sufficient, except when many tendons have to be cut at the same time, and then nitrous oxide

and ether may be administered. Not a little of the success of these small operations depends upon the administrator of the anæsthetic. He should push his anæsthetic just so far as not to cause the muscles to lose their contractility, and therefore not abolish the tension of the tendons. This requires expert knowledge, and adds greatly to the comfort of the operator, who prefers to have a tense tendon to cut against rather than a flabby one.

Although it is not quite within the scope of this work, yet a word may be said as to the peculiar reflex of the foot. During anæsthesia, long after the corneal reflex has disappeared, the foot readily responds to stimuli, and the patient may begin to kick the moment the knife enters the skin. More particularly is this the case if the foot has been the site of severe pain, such as in old-standing cases of bunion and in Morton's disease. The unskilful administrator is therefore likely either to give an insufficient dose, so that the patient struggles, or in his efforts to render the muscular system entirely lax to overdose the patient. More often the first condition is seen. The administration of nitrous oxide can be satisfactorily prolonged if mixed with oxygen, a method which was originated and perfected by my friend Sir F. Hewitt.

When tenotomy is combined with wrenching, gas and ether should be administered. As a rule chloroform, except in operations about the neck, should be avoided, and in young infants no anæsthetic is necessary. Local anæsthetics, except perhaps eucaine and adrenalin, are not desirable, and this remark particularly applies to cocaine. The dangers of injecting it are now fully appreciated. With regard to spinal anæsthesia, the writer is not satisfied as to its freedom from grave danger, and he prefers to use anæsthetics of the types advocated.

Accidents in the course of Tenotomy.—In the performance of this small operation the chief risks are wounding arteries and veins and the severance of nerve trunks. As to the arteries, it is not uncommon, in dividing the tibialis anticus, for a jet of arterial blood to follow the withdrawal of the tenotome; and section of the plantar fascia and short muscles of the sole, if at all deep, must involve the internal plantar vessels and nerve. Such events in the extremities are of little importance; a pad firmly applied suffices to arrest all hæmorrhage. It is better to divide the small artery completely than to puncture it, as the risk of aneurysm is less. There are certain positions in which open section of tendons and muscles is imperative. Such are division of the sterno-

mastoid in the neck and the biceps tendon at the elbow and behind the knee. In the first case the subclavian vein, rising high in the neck, has been punctured and required ligature, and in the last case the external popliteal nerve has been severed several times.

Accidents after Tenotomy.—1. *Suppuration.*—Walsham and Hughes[1] mention that they have seen suppuration in one case of division of the tendo Achillis. Sometimes suppuration occurs during the prevalence of influenza, especially when the patient is either suffering from it or has recently had it. As a rule the possibility of suppuration in subcutaneous tenotomy is a negligible factor. In open sections of the tendons, with aseptic precautions, it should never occur.

2. *Aneurysm.*—In eighteen years the writer has had two cases of aneurysm of the internal plantar artery. In one it was necessary to open the aneurysm and turn out the clot, and in the other the pressure of a pad and bandage sufficed to cure it.

3. *Hæmorrhage.*—In the extremities this is of little moment. Digital pressure at the time, followed by a pad and bandage firmly applied, arrests the flow of blood.

4. *Non-union of Tendons.*—This event is extremely rare. The risk is not so much of non-union, as of too long and feeble union. A tendo Achillis requires six weeks to heal soundly, especially in infantile paralysis, where the tendon is often small and badly supplied with blood. Some surgeons err greatly in allowing their patients to walk too soon, and with the tendo Achillis insufficiently protected. We repeat here that the result is a very troublesome form of talipes calcaneus, which until recently was incapable of remedy, but now happily can be dealt with on the following lines.

A New Form of Operation for Talipes Calcaneus resulting from Excessive Elongation of the Tendo Achillis.—Several cases had come under the writer's observation which he found very difficult to treat. He devised the following method of dealing with them:—

On cutting down to the site of the former operation he observed that between the ends of the severed tendon a long thin membrane extended, indistinguishable from the surrounding fibrous tissue. He found the best method of dealing with these cases was to excise this thin membrane completely, and not to attempt to join directly the tendon ends, as it would merely reproduce the

[1] *Deformities of the Foot*, p. 191.

original condition of talipes equinus; for in some cases the union stretches so rapidly that talipes calcaneus again occurs. He therefore employed Lange's method of artificial silk tendons. The foot is placed at a right angle, and a strand of silk of No. 2 size is passed five or six times from one tendon end to the other, taking care to make a little tension on the proximal end. At the end of three months the tendo Achillis is firmly re-constituted, new tendinous material having formed along the guiding lines of the silk, and the patient is able to lift the weight of the body upon the foot. There is now no risk of stretching.

Causes of Failure in Tenotomy.—1. *Imperfect Division of a Tendon.*—This event occurs occasionally in an operation on the tendo Achillis. It is either transfixed, leaving the deeper part intact; or a small portion of the superficial part may remain undivided for fear of cutting through the skin; or the plantaris tendon on the inner side may escape section.

2. *Missing the Tendon.*—This is more likely to occur in a fat infant in the case of the tibialis posticus than elsewhere.

3. *Clumsy Division*, with extensive laceration of the sheath and soft parts, causing matting and firm adhesion of the tendon to the neighbouring structures.

The Question of Immediate and Gradual Reposition of the Part after Tenotomy.—Many writers on general surgery advocate immediate reposition of the part in all cases, but there are many points to be considered before accepting this wholesale advice.

1. If an artery has been pricked or divided, recurrent hæmorrhage is less likely to take place if the limb is returned to the position of deformity for three or four days, until a firm clot has formed in the artery.

2. On the relations of the sheath and the tendon, the elasticity of the tendon, and its capacity for retraction when divided, much must depend. When we discuss functional prognosis of tendon suture on page 769 we shall find that in some situations the tendon ends retract two and a half inches, and in others not more than half an inch. It is certain, however, that an interval of one inch in the tendo Achillis will not interfere with firm union and subsequent function, while the same amount of retraction in the flexor tendons of the hand will seriously impair the functions of the part.

Then again it is advisable to consider the strength and tension of the affected muscles and their opponents. In a spastic or congenital case the quiescent interval after division ought to be greater

than in paralytic cases, since the tendons of the affected muscles are in a state of greater tension than normal, and the ends fly apart more on division.

In connection with the question of the immediate or gradual reposition of the part after tenotomy, most of the difficulties arise in relation to the tendo Achillis and the tendons of the hand. With the former, if the tendon be immediately lengthened to its full extent, and the case passes from observation after a week or two, so that the union is not kept under control for the proper period of six weeks, the band becomes unduly long and weak, and calcaneus inevitably follows. When we have to deal with the tendons of the hand the greatest care is necessary to regulate the length of the uniting band between the ends. In dealing with the tendons of the foot the matter is on a different basis. The function of the foot is that of support and not of fine movement. In many instances, therefore, except in the tendo Achillis, a long band of union is desirable, and immediate reposition is advocated.

The matter then is not one for dogmatism in any shape or form, but it is one requiring wide experience and the nicest appreciation of the problems involved.

Section of the Plantar Fascia.—The contracted bands should be clearly located with the finger-nail, after fully stretching the sole of the foot. The bands usually affected are on the inner part of the sole and inner border of the foot. This latter band is often neglected, and causes delay in reducing the deformity; it is also responsible for persistence of adduction of the great toe, or pigeon-toe. The practical point is that after division of the superficial bands deeper ones come into prominence, and necessitate wider section than at first seemed necessary. The operation is an extremely simple one.

An assistant should firmly, but lightly, with finger and thumb, hold the head of the metatarsal bone of the great toe in such a way as to render prominent by careful movements those bands which need division. With the other hand he fixes the heel. The spot for division of the fascia is one-third nearer its attachment to the os calcis than to the roots of the toes, because posteriorly the fascia is not split into several divisions, and it is more completely divided by one incision. And if, in the event of one operation proving insufficient to relieve the contraction, others are required, there is a greater length of fascia free from scar-tissue anterior to the site of the first section, than when the latter has been made at the mid-point.

It is better to pass the knife between the skin and the fascia, and cut towards the bones, because the attachment of the fascia to the skin is so close that if the operation is done in the reverse direction the skin may be divided as well. A small but practical point is that as little blood-clot as possible should be left between the ends of the fascia, and the surgeon's thumb should follow the blade of the knife, and press out any blood beneath the skin. Immediately the knife is withdrawn a pledget of gauze should be firmly applied so as to prevent effusion. This is to prevent the formation of a mass of scar tissue, which is almost invariably painful, and worries the patient for three or four months, or even longer.

After the operation, the sole of the foot is kept at rest for ten to fourteen days, and then stretching may be commenced. By thus waiting a few days the formation of a painful cicatrix is avoided.

Some surgeons practise a wholesale subcutaneous division of all the structures of the sole of the foot without reference to arteries and nerves. This is practically a subcutaneous Phelps' operation, and for the less degrees of deformity is not necessary.

Careful dissection away of the contracted fascia in the sole, as is sometimes done in Dupuytren's contraction of the palmar fascia, has been practised, but it frequently leaves behind a matted condition of the plantar structures. In any case sufficient elongation can usually be secured by subcutaneous section and the use of the wrench.

Section of the Tibialis Anticus.—It is well to remember that the tendon is often displaced somewhat inward in talipes equino-varus, but it can always be felt.

The patient lying supine, the tendon is accurately defined on the dorsum of the foot, and the tenotome, held flat, is passed beneath it just below the line of the ankle joint, and from without inwards so as to avoid the dorsalis pedis artery. Section of the anterior fasciculus of the internal lateral ligament may be combined with this operation. After division of the tendon, the edge of the knife is turned downwards and a clean subcutaneous cut is made at the anterior border of the internal malleolus so as to divide the contracted ligaments. The extensor longus hallucis is also severed on the dorsum of the foot, midway between the ankle and the first interdigital cleft.

Tenotomy of the Tibialis Posticus.—This tendon is severed, preferably about an inch above the internal malleolus. The text-

books speak of a small prominent spine, the posterior tibial tubercle, on the posterior edge of the internal malleolus, and at the junction of this process with the shaft. It is advised that the tendon be divided behind this spot, but there are several objections. Firstly, this point of bone is absent in children; secondly, the tendon is entering the synovial sheath in the annular ligament, and complete division is difficult; thirdly, in fat infants it is often impossible to define the outline of the internal malleolus, particularly when it is so feebly developed, as in equino-varus. The best method is the following, especially when operating on infants:—

If for instance the right foot is the affected one, the child is turned on to its right side, so that the outer aspect of the leg lies as flat as possible on the table. The left knee is flexed, and the left foot is thus out of the way The operator stands on the left side of the patient, and the assistant, facing him, holds the foot extended, inverted, and adducted, so that the tibialis posticus and flexor longus digitorum are relaxed. The surgeon now marks a point about one inch above the tip of the internal malleolus, and exactly midway between the anterior and posterior margins of the leg. Holding the knife vertically, and with the flat of the blade parallel with the long axis of the tibia, the point is passed in perpendicularly to the skin, and is carried on steadily until the inner edge of the tibia is met. This is the guide to the tendon. If the edge is not felt, it is sought for with the point of the knife. The edge of the knife is now turned backwards towards the tendon, and the assistant dorsiflexes, everts, and abducts the foot, thus tightening the tendon. This movement is in infants often sufficient to make the section without any further effort on the part of the operator. In older children a gentle sawing movement suffices. To include the flexor longus digitorum the knife is buried a little deeper, and it is divided at the same time. In all cases a jerk or jerks should be felt, and the foot is at once found to be capable of more eversion. If on withdrawing the knife a jet of bright blood follows, with sudden blanching of the foot, the posterior tibial artery has been wounded. Oozing of dark blood indicates puncture or division of the internal saphenous vein, but neither of these events is of much importance, for the pressure of a pad and placing the foot on a splint in the deformed position always arrests the hæmorrhage.

In more instances than are usually suspected the tibialis posticus escapes division on account of the nervousness of the operator with regard to the artery.

Division of the Peroneus Longus and Brevis is made about one and a half inches above the external malleolus, the knife being passed either from the front or the back beneath the tendons, and the section made towards the skin.

Section of the Extensor Longus and Brevis Digitorum is done behind the heads of the metatarsal bones. Considerable venous hæmorrhage often takes place when the tendons of the second toe are divided.

Section of the Tendo Achillis.—The spot selected for division is the narrowest part of the tendon, a short distance above its insertion. If the knife is entered higher up, the posterior tibial artery may be wounded, there is greater thickness of tendon to divide, and the plantaris tendon may not be included in the section. It is generally recommended that the knife be entered on the inner side, but in equino-varus the tendon is almost invariably displaced inwards, the posterior tibial artery is nearer to it than normal, and there is a risk of puncturing the artery when the point of the knife is entered on the inner side. To a skilful surgeon, however, it matters little which side he chooses.

The tendon is relaxed by the assistant as the knife passes beneath it, and is then stretched as the division is being made. Section of the tendon must be complete. Two causes of failure are common:

(*a*) Want of boldness in passing the knife beneath the tendon, so that it is transfixed, and the superficial part only cut;

(*b*) A small band, possibly part of the plantaris tendon, on the inner side escapes section.

In applying the pad of gauze to the wound care should be taken to put it on gently, so that the skin may not be compressed between the tendon ends, and partially block the sheath. For perfect union the sheath must be well distended with blood, and excessive pressure of a pad prevents this.

Subcutaneous Section of the Posterior Ligament of the Ankle.—This may be combined with section of the tendo Achillis, and in many cases it should be done. After dividing the tendon the edge of the knife is turned forwards, and a steady cut is made through the ligament into the ankle joint. In all marked cases of equinus this should be done.

Syndesmotomy—Subcutaneous Section of the Astragalo-Scaphoid Capsule. (R. W. Parker).—At this operation the tendons of the tibialis anticus and posticus, and the ligaments forming the astragalo-scaphoid capsule, can be subcutaneously divided at one

stroke on the inner side of the foot. The capsule is made up of the superior astragalo-scaphoid ligament, the anterior portion of the deltoid ligament of the ankle joint, and some fibres from the inferior calcaneo-scaphoid ligament, to which are united fibrous expansions of the tendons of the tibialis anticus and posticus.

The knife is entered immediately in front of the anterior border of the internal malleolus, between the skin and the deeper structures, and the blade is then turned towards the surface of the ligaments, and they are divided. As the superficial fibres yield, deeper ones come into play, and the cutting is continued until the bones are reached. By dipping the knife towards the sole of the foot some fibres from the inferior calcaneo-scaphoid ligament can be divided. During the section the ligaments should be made tense by forcibly abducting and everting the foot, and care should be taken not to cut beyond the tip of the internal malleolus, so as to avoid wounding the posterior tibial artery.[1]

Wrenching.—It is done either with the hand or by means of specially constructed wrenches. In the club-foot of infancy and early childhood the hand is preferable and all-sufficient, but the severer degrees are treated by the wrench.

If rapidity in reducing the deformity is aimed at there is no method so quick and so safe as wrenching, preceded by tenotomy. Some surgeons prefer to do the cutting part of the operation a few days beforehand, and allow the punctures to heal. Others, trusting to their aseptic precautions, wrench at the same time as tenotomising.

When wrenching is carried out with the hands the movements are the same as those practised in manipulation, but they are made under anaesthetics and with more force (Fig. 227) and sometimes over a wooden wedge, plaster of Paris often being afterwards applied. The keynote to the success of wrenching, whether with the hand or by apparatus, is that when the wrenching is finished the foot should lie limp and flabby, and capable of much over-correction in every direction.

The varieties of wrenches and the methods of using some of them will be considered when we are dealing with neglected and relapsed club-foot.

[1] Bradford and Lovett (*op. sup. cit.* 3rd ed. p. 535) remark that the calcaneo-cuboid ligament should also be divided in severe cases. The tenotome is inserted a short distance behind the base of the fifth metatarsal bone, near the calcaneo-cuboid articulation, and the ligament severed by cutting down to the bone.

RECAPITULATION.—We may now review the first stage of the treatment of infantile club-foot. Manipulation of the part ought to be commenced by the nurse after birth, and then, if required, surgical methods can be commenced. In the second degree tenotomy of the tibialis anticus and posticus, and section of the ligaments in front of the internal malleolus, are generally called for. This operation is accompanied or followed by successive wrenchings with the hand until the foot is in a valgoid position, and remains there. Then the tendo Achillis and posterior ligaments of the ankle are severed, and the equinus is reduced quickly. Until the child walks some form of retention splint is necessary, and the simple shoe described on p. 247 fulfils all requirements.

If the surgeon elect to proceed more rapidly, the varus is disposed of at one sitting, over-correction is secured, and the foot is placed in plaster of Paris. When the reduction and over-correction of the varus are entirely satisfactory, the equinus is treated in the same way. In our experience relapse is more frequent when feet are treated by the plaster of Paris method than when splints are used, and this is certainly more frequently the case in general than in special hospitals. Too much of the post-operative treatment is left in the hands of dressers in general hospitals, and frequently cases are lost sight of for a considerable period.

Rapid correction of the deformity, by whatever method accomplished, is eminently desirable, as in the first month of life the bones are entirely cartilaginous and elastic, and the sooner the direction of normal growth is attained, the quicker will the bones assume their natural shapes, and their internal structure be altered.

SECOND STAGE OF TREATMENT OF INFANTILE CLUB-FOOT

This comprises support and restoration of function. Until the child is able to walk the foot should be retained in an over-corrected position, and for this purpose a simple shoe (Fig. 201) is used. This is removed morning and night, the parts passively exercised and rubbed, especial care being taken to massage the peronei muscles, so as to restore the muscular balance as completely as possible. When the child is able voluntarily to dorsiflex and abduct the foot fully, the result so far is eminently satisfactory, but if the case be now abandoned relapse is almost inevitable.

When the patient walks it is necessary to supply him with what is termed in England "walking apparatus" or "irons," or in

America a "retention-brace." Several forms of these are in use (Fig. 202). Their objects are—

1. To retain the foot in the over-corrected position, and to facilitate the influence of normal function in the re-moulding and re-shaping of the bones.

2. To overcome the excessive inversion of the limb.

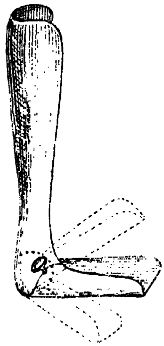


FIG. 201.—Tin Shoe, with Quadrant Movement at the Ankle, used as a retention apparatus for night wear after reduction of Talipes.

It is frequently forgotten that club-foot is merely an exaggerated expression of the excessive inversion of the whole limb. Therefore, while the foot may be in normal relationship to the leg, the latter is itself inverted, and therefore the foot in walking is twisted inwards. By applying a brace with an everting action the limb is gradually turned outward and the twisting overcome. In order to do this the apparatus must have a fixed point, and the nearest fixed point is the pelvis. Therefore the rule in applying walking apparatus to young children is that it should extend to the pelvis. There is frequently much laxity of the ligaments of the knee-joint, and the leg can only be controlled when the knee is kept extended. It is well not to have a free joint in the apparatus at the knee, but to fix it with a pin temporarily. When the foot is no longer inverted in walking, the pin may be removed. At night it is advisable that the tin shoe should be worn, but it need not extend up higher than the calf. This second stage then merges into the

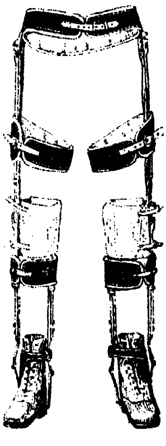


FIG. 202.—Walking A paratus for the aft treatment of Conge ital Talipes Equin Varus.

THIRD STAGE OF TREATMENT

Supervision.—This includes active exercises on the part of the child without an apparatus. He should be encouraged to walk, to turn the foot well out, and to dorsiflex it, all without the use of any apparatus. Massage of the evertors and dorsiflexors is still assiduously practised, but the important factor is active exercise of the foot in as close a position to the normal as possible. Too long

retention of apparatus leads to atrophy and shortening of the leg. Nevertheless apparatus should not be discontinued until the surgeon is able to satisfy himself on several occasions that the child is putting his foot to the ground in an entirely natural position. Then and only then can the treatment be regarded as successful, and the responsibility of the surgeon cease. Relapses occur both in the second and third stages of treatment, and more frequently in the latter than in the former.

Duration of Treatment.—The first stage lasts for about three months, the second stage until the period of walking, and the third stage may extend over some years. It can be appreciably shortened by careful attention to the details described. The less complicated and costly the apparatus employed in the treatment of infantile club-foot, the better. The same ends can be secured by simple splints or by plaster of Paris. The criterion of cure is the steady maintenance of the foot to the front in all positions, whether standing, sitting, or lying.

Treatment of Complications, especially Inversion of the Limb, and of Genu Recurvatum

Inversion may exist—

(*a*) In the shaft of the tibia, that is, it is unduly twisted inward on a longitudinal axis; or, as some authors maintain, it is not sufficiently twisted outward in development, and in that respect resembles the anthropoid apes, in which the external malleolus is in front of the internal.

(*b*) At the knee-joint, a very frequent condition, and often associated with lax ligaments and genu recurvatum.

(*c*) In the long axis of the femur.

(*d*) At the neck of the thigh bone, in such a way that the anterior margin of the great trochanter looks forwards and inwards, that is, the neck is incurved.

Inversion of the leg is ascertained by taking two points, the inner side of the great toe and the inner edge of the patella. In the normal limb they are in one plane, which is parallel to the median vertical plane of the body. If, when the leg is placed so that the anterior surface of the patella looks directly forward, the foot being fully extended on the leg, it is found that the great toe is inside the vertical line above mentioned, then inversion is present

somewhere below the knee. The foot, however, may be perfect in shape and in its relation to the leg, and yet look inward as a whole. In this case the cause of the inversion is clearly between the knee and the ankle, and is usually due to a spiral twist in the bones of the leg (Fig. 203).

If the cause of inversion is in the ligaments of the knee-joint,

FIG. 203.—From a case of Talipes Equino-Varus, where the deformity of the feet had been rectified, but Inversion persisted on account of the excessive Inward Rotation of the Leg.

FIG. 204.—The Inversion of the foot shown in the previous figure has been remedied by Osteotomy of the Tibia and Fibula.

rotation outward of the extended leg and foot to the front is easily possible. When the twist is more marked and is in the shaft of the femur, the outer surface of the great trochanter will have its normal direction, but the limb below will be inverted, and the inner edge of the patella and the inner margin of the great toe, though lying in the same plane, will be inside their normal position. Finally, if the inversion is in the neck of the femur, the outer surface of the

trochanter will look forward, and the foot and knee may be brought to the front by rotating outward at the hip-joint. In many cases the inversion extends in a spiral twist throughout the whole limb, but as a rule it is most marked at the knee-joint and in the bones of the leg.

Treatment of the Inverted Limb.—While the child is young the upper part of the thigh should be held firmly grasped by the surgeon, and after manipulation of the foot the limb should be forcibly rotated outwards. When the ligaments of the knee-joint are lax, the leg should be grasped just below the knee, and an outward twist given to the tibia and fibula. In older children, when the twist is in the bones of the leg, these manipulations are not sufficient. In 1894 the writer performed his first osteotomy for a case of this description (Fig. 204). It was found necessary in this case to rotate the lower fragment of the bones of the leg through a quarter of a circle.

In place of osteotomy, osteoclasis at the middle of the leg is performed, and of recent years it has been preferred by the writer to osteotomy.

While the limb can be gradually twisted outwards by manipulations and the prolonged use of walking apparatus, yet as a saving of time osteoclasis is excellent.

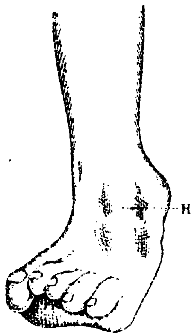


FIG. 205.—View of a left foot, showing Relapsed Congenital Talipes Equino-Varus in a child of 12 years of age. At H is seen the prominence formed by the outer part of the Head and Neck of the Astragalus. For the drawings 205-212 the author is indebted to his friend, Mr. E. Rock Carling.

TREATMENT OF NEGLECTED AND RELAPSED CLUB-FOOT

These are taken together, as in most instances the deformed condition is very similar. The causes of relapse or imperfect cure are the following:—

1. Incomplete or insufficient division of fasciæ, tendons, and ligaments; or if wrenching has been adopted, insufficient stretching of the contracted parts.
2. Want of prolonged supervision, which may be due either to inattention on the part of the surgeon or to carelessness and neglect by the parents.
3. Absence of recognition of the important part played by the

proper functional use of the foot in a correct position, and leaving off apparatus too early.[1]

In neglected cases the chief factor is delay in commencing treatment. The use of a deformed foot perpetuates the deformity; walking with a corrected foot is the best means of cure, so that the earlier treatment is begun, the better is the outlook.

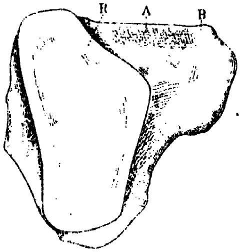


FIG. 206.

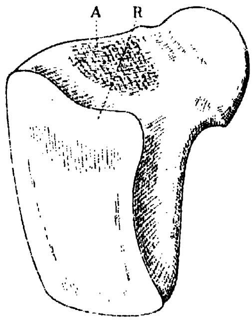


FIG. 207.

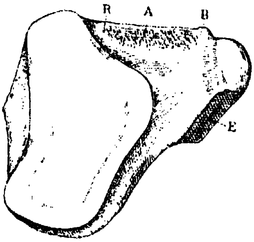


FIG. 208.

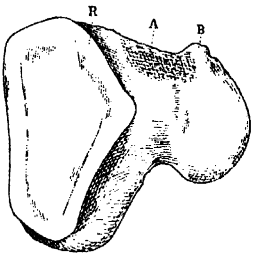


FIG. 209.

FIGS. 206-209.—Drawings of some Astragali removed by the author from cases of Relapsed Congenital Talipes Equino-Varus. In all, A is the Rough Surface on the outer aspect of the head and neck of the Astragalus; R, Bony Ridge, which locks against the lower end of the Tibia; B, Bony Tubercle (prefibular tubercle), at anterior end of abnormal external surface on the head and neck of the Astragalus; E, new facet for articulation of Astragalus with external malleolus.

TYPES OF NEGLECTED AND RELAPSED CLUB-FOOT

1. **Due to Insufficient Dorsiflexion at the Ankle.**—The cause of this, and in my opinion the chief cause of relapse in club-foot, is that the equinus deformity is not reduced in infancy and early

[1] The opposite error must be avoided. If the limb is kept too long in irons, the natural development is retarded and shortening often ensues.

childhood. The tendo Achillis has been divided, but the foot cannot be dorsiflexed to less than a right angle, and in some cases not even to the right angle (Fig. 205). The cause lies primarily in the astragalus.[1] The upper and outer non-articular portion of the astragalus is seen to form a more or less quadrilateral surface (Fig. 210, A) interposed between the tibia T and cuboid P (Fig. 211), effectually preventing complete upward flexion of the foot. In fact, before the anterior ligaments are divided this abnormal surface appears to be directly continuous, and is approximately in the same plane as the outer and anterior surface of the tibia (Fig. 211). The appearances depicted in Fig. 213 show how complete the bony block is. Figs. 206-210 are taken from astragali removed from relapsed and imperfectly cured congenital equino-varus. In Fig. 210 the head and neck of the astragalus are inverted or twisted inward to a greater angle than normal. In all the cases, however, we see the more or less marked rough and irregular surface A, just described as being coterminous with the antero-external surface of the tibia. In all, again, we see at B, a prominent bony tubercle, the prefibular tubercle, which is often felt in these cases, even in infants, on the outer and upper aspect of the foot. The anterior edge of the upper articular surface of the astragalus forms a prominent lip R (Figs. 206 - 209), obviously parallel with and projecting against the anterior edge of the inferior

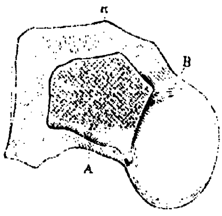


FIG. 210.—View of an Astragalus taken from above from a severely Relapsed Case of Congenital Talipes Equino-Varus. A, B, Abnormal Quadrilateral Surface. R, Summit of Bony Ridge, causing locking at the Ankle-joint.

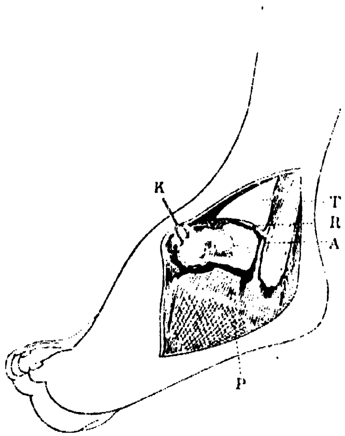


FIG. 211. — Illustrating the position of the neighbouring bones in Fig. 210, and the obstacle formed by the rough Quadrilateral Surface A, K on the outer part of the neck and head of the Astragalus, which effectually prevents Normal Dorsiflexion at the Ankle. T, Tibia. P, Cuboid. R, Upper Boundary of Quadrilateral Surface A, K, locking against Lower Border of Tibia. A, Fibula.

[1] A. H. Tubby, "Discussion on the Treatment of Club-Foot," *Brit. Med. Jour.* October 9, 1909.

articular surface of the tibia, and rendering it absolutely impossible to force the astragalus farther upwards—the impossibility being due not only to locking of the contiguous bony edges, but also to the fact that the bulk of the astragalus is greatly increased in front of this joint; an increase which commences at the anterior and outer extremity, is exaggerated throughout the quadrilateral rough surface A, and reaches its culminating point in a ridge R (Fig. 213) at the anterior part of the ankle-joint.[1] The treatment is obvious—remove the causes of obstruction, performing either partial or complete astragalectomy.

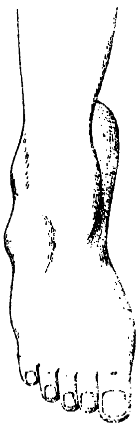


FIG. 212.—View of a Right Foot from a Case of Relapsed Congenital Equino-Varus. H, Bony Prominence at outer side of head and neck of the Astragalus.

These obstructive conditions can be recognised by making an attempt to dorsiflex the foot, and noting the tension of the tendo Achillis at the same time. It does not become firm and hard, but is yielding and elastic. Further, at a certain point in dorsiflexion the absolute resistance arising from a bony block is felt. The heel is often ill developed, and the skin is soft and thin over the tuberosities of the os calcis. The patient cannot flex his foot, abduction to a proper extent is not possible, and he allows the foot to fall into its easiest position, namely, inversion, so that it rapidly becomes varoid again.

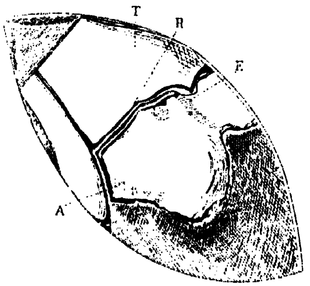


FIG. 213.—View of the parts during an Operation for Astragalectomy on the foot in Fig. 212. T, Tibia. A, Abnormal Surface on the Astragalus. R, Ridge on the Astragalus locking against the tibia. E, Abnormal Facet for Internal Malleolus.

It is useless in this type of case merely to stretch the structures about the medio-tarsal joint, or to divide them. At all costs the astragalus, or part of it, and after astragalectomy the upper surface of the os calcis, must be made to fit into the ankle joint. The methods by which this can be accomplished are detailed on pp. 287, 288.

2. **The Congenitally Varoid Foot.**—In this type (Fig. 168)

[1] I am indebted to my friend and colleague, Mr. E. Rock Carling, for the figures illustrating the abnormal conditions of the bones in relapsed congenital equino-varus.

pigeon-toe is a very marked characteristic, and there is a general varoid twist of all the bones of the foot in front of the ankle joint. The foot is rigid and resistant, and feels as if set in plaster of Paris. In effect the inner side of the foot forms part of the circumference of a circle of no great diameter. The patient walks on the outer edge, the soft tissues being thickened, and corns and adventitious bursæ present.

3. In the *third type* there is a peculiar *inward twist of the heel* (Fig. 195), and if the affection be bilateral, when the patient stands the heels project inwards and are ball-like in shape, particularly when viewed from behind. This condition is due to twisting of the os calcis, and with it the front part of the foot. The os calcis is tilted, so that its inner surface looks upward and inward, instead of directly inward, and its outer surface downward and outward, instead of outward. This type of deformity is difficult to cure by means of apparatus or by wrenching, on account of the small purchase which can be obtained on the os calcis. The writer has practised division of the ligaments and resection of the calcaneo-astragaloid joint with success.

4. The most marked type, or what may be termed *inveterate club-foot*, has the characteristics of the three above-mentioned types combined—the ball-like heel, the pigeon-toe, the inward twist of the foot, and the inability to flex at the ankle are all marked. The sole of the foot looks directly inward, or it may be upward and inward, the patient walks entirely on the outer side or even on the dorsum, and the part is truly clubbed (Figs. 214-218).

Treatment of Neglected and Relapsed Club-Foot

This comprises also the third and fourth degrees which are seen both in children and in adults.

The third degree is an exaggeration of the second degree, but with a much greater resistance of the foot to reposition. The impression given to the hand of the surgeon is as if the structures of the foot were partially glued together. The changes in the articulations and bones, described on pp. 232, 233, are well marked and are evident on external examination. Thus the tip of the internal malleolus closely approximates to the scaphoid, the cuboid is very prominent, and the head of the astragalus can be felt externally.

In the fourth degree all these changes are still more marked, and the external appearances are well shown in Figs. 214-218.

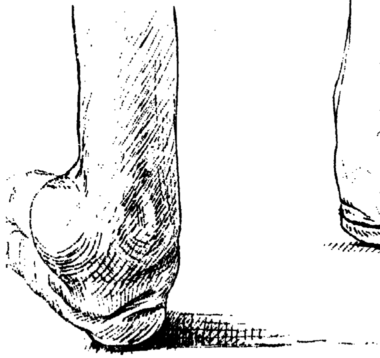


Fig. 214.

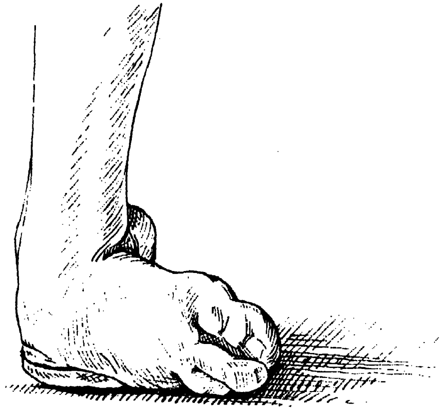


Fig. 215.

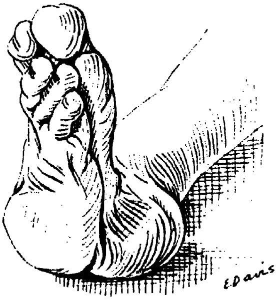


Fig. 216.

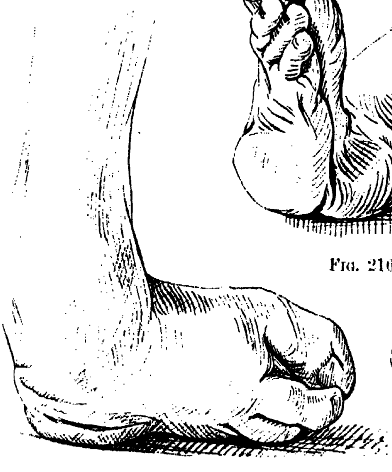


Fig. 217.

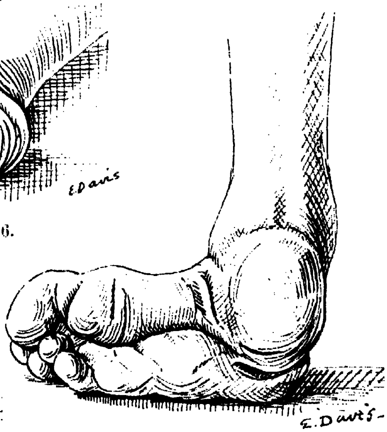


Fig. 218.

Figs. 214-218.—Inveterate Type of Non-treated Congenital Talipes Equino-Varus.

In Fig. 214 the Inversion of the Sole and Longitudinal Crease appears. The Heel is twisted entirely inward, and the Tread is upon a prominence partly upon the Dorsum and partly on the Outer Side, which is covered by a False Bursa.

Fig. 215.—Front View of the same.

Fig. 216.—The Foot is laid on its Posterior and Outer Part, so as to show the Inward Rotation and Creasing of the Sole and the Crowding of the Toes.

Fig. 217.—The Usual Position assumed in Walking.

Fig. 218.—Posterior View of Fig. 217.

In dealing with these types we have a large choice of methods, some comparatively mild, and others involving severe bony operations. Formerly, attempts were made to cure the deformity of this type by tenotomy, persistent manipulation, and gradual moulding of the foot in a Scarpa's shoe. But this method, though successful, took months, and therefore surgeons have been driven to devise more rapid means of overcoming the difficulties.

We now enumerate and describe the methods. They are as follows :—

I. Forcible Rectification.
  (*a*) After the method of Lorenz.
  (*b*) After the method of Julius Wolff.
II. Reduction by Wrenching.
III. By subcutaneous division of all resistant structures, followed by manipulation or wrenching.
IV. Phelps' Operation, or open division of resistant structures.
V. Various forms of Bony Operations.

I. **Rapid Correction of the Deformity by Forcible Rectification.**—The remarks which were made on the mechanical treatment of the less severe degrees of club-foot on p. 253 apply more forcibly here. Not only must the foot be over-corrected, but it must be kept in this position until it shows no tendency to relapse. Further, this position must be maintained until the relations and shape of the bones have undergone a reversion to the normal. Finally, time must be given for the restoration of the muscular balance. The treatment merely begins with the operation, which is not in itself curative, but simply serves to place the foot in the right line. Normal development is a matter of time and of considerable trouble, and requires careful watching on the part of the surgeon.

(*a*) *Forcible Rectification by Lorenz's Manipulations.*—The patient is fully anæsthetised, and the various elements of the deformity are attacked in turn: first, the adduction at the medio-tarsal joint; secondly, the inversion of the sole; thirdly, the excessive plantar flexion of the sole; and, fourthly, and most difficult of all, the plantar flexion or defective dorsiflexion at the ankle.

If it be the left foot which requires correction, the heel is grasped by the surgeon with his right hand, so that the thenar eminence lies against the most prominent part of the os calcis and cuboid. Over the thenar eminence as a fulcrum the inverted foot is bent by grasping the fore-foot firmly with the left hand and

carrying it outwards, gently at first, but with gradually increasing force, until the shortened structures on the inner side are felt to give. This manœuvre suffices for the less severe cases, but for the more severe the wedge should be used. The apex of the wedge is covered by a thick layer of indiarubber. The foot is laid on its outer side on the wedge, and the surgeon presses on the inside of the heel with one hand, and on the inner side of the first metatarsal bone with the thenar eminence of the other, and by vigorous movements in a downward direction the resistance is gradually overcome. The foot should, finally, be so lax that it shows no inward elastic recoil whatever, and can not only be held straight with the leg, but also can be abducted with a very little force, such as can be applied with one or two fingers.

The second stage is overcoming the inversion of the sole. The leg is grasped round the ankle by the surgeon with his left hand, and with his right the foot is forcibly twisted downward and outward many times, and with gradually increasing force, until it is everted, and the sole looks, not downward and inward, but downward and outward. It is easier to carry out this manœuvre in bad cases if the foot is laid on the wedge so that the apex of the latter lies just in front of the internal malleolus.

The third series of movements is designed to stretch the contracted plantar fascia, and reduce the excessive concavity of the sole. This is done by grasping the foot with the right hand around the heads of the metatarsal bones, and steadily pressing the foot upwards against the resistance of the ankle joint and of the tendo Achillis, until the sole is flat.

The fourth part of the rectification is the most difficult. Its object is to force the astragalus firmly upward and backward between the malleoli. The tendo Achillis and posterior ligament of the ankle are divided subcutaneously. The patient is then turned upon his face, and the knee is bent to a right angle, so that the limb rests upon the table with the leg upright. The surgeon now hooks the fingers of his right hand above the projection of the heel, and with the palm of the hand and front of the wrist lying on the sole of the foot draws upon the heel with the fingers, and presses the foot steadily upwards into dorsiflexion. The pressure is alternately relaxed and renewed until reduction is more than complete. But herein lies the difficulty. There is often some degree of obstruction at the ankle, which refuses to yield. Lorenz often assists his leverage movement at the ankle by placing a bandage over the front

of the joint (Fig. 219), and pressing the foot upwards. He has also devised a special wrench for the purpose of overcoming the difficulties in very rigid cases.

The main advantage of the operation is that, when successfully carried out, rectification is rapid and complete. The disadvantages are that great force is required and accidents happen, such as separation of the lower epiphysis of the tibia and fibula or fracture of the bones of the leg. In unskilful hands so much bruising may

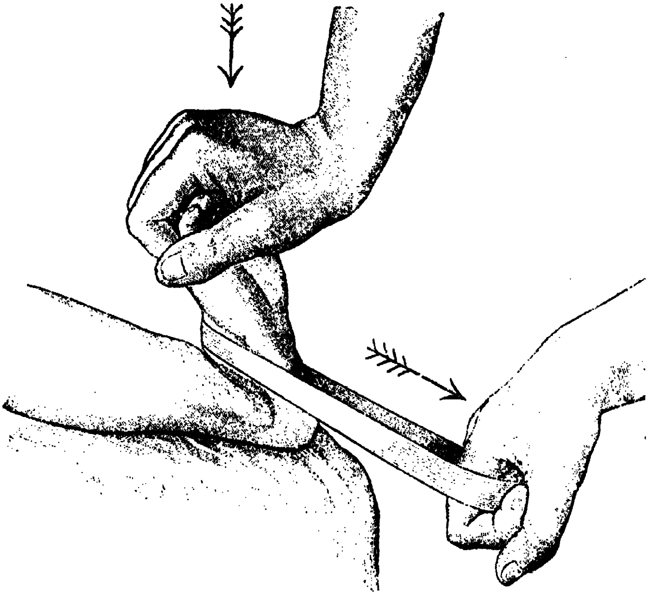


FIG. 219.—Method of overcoming the Equinus Deformity by the use of a bandage and forcible manipulation (Lorenz).

take place that interference with circulation may occur and possibly sloughing. It also requires no little personal exertion on the part of the operator, and he will have to work very hard for at least twenty minutes to half an hour. It is astonishing, however, to note how a foot, at first entirely resistant, gradually yields in the various directions. Positions, which at first seem to be impossible, are gradually attained, and at the end of the procedure the foot lies limp in every direction, and can be placed fully in over-correction.[1]

[1] A criticism which has been made, both upon forcible manipulation and forcible wrenching, is the possibility of tuberculosis of the bones of the foot supervening. In one case I have known this to occur. In fact it is a marvel to me that after the extensive

By many surgeons this procedure is regarded as the operation of choice. Personally the writer prefers to use it in that type of neglected or relapsed club-foot in which the inner border of the foot is markedly concave and all the structures of the foot are rigid. It is manifestly impossible to divide subcutaneously all the affected structures, and therefore forcible manipulation and wrenching, affecting every structure of the foot as they must do, constitute the best method of treatment.

At the conclusion of the manipulations the foot will be somewhat congested owing to the pressure of the fingers, but it is warm and the circulation is good. It must now be fixed in a plaster bandage in the over-corrected position. A layer of cotton wool is applied from the tips of the toes to the middle of the thigh. The layer should be thickened over the external malleolus, and the wool must be placed evenly so that there are no wrinkles in it. A plaster of Paris bandage is now applied with the foot held abducted, everted, and dorsiflexed. The bandage reaches from the tips of the toes to the middle of the thigh, and the leg is rotated outwards at the knee-joint. As the bandage sets, the over-corrected position is maintained, and the limb is held perfectly steady, so that no wrinkles may form and cause pressure on the skin. It is always advisable to carry the bandage well up to the middle of the thigh, so as to control the eversion of the limb; and if this is marked the knee may be slightly flexed before putting on the bandage. Before the plaster is set entirely, windows are made over the external malleolus, the front of the ankle, and the ball of the great toe. These are the spots where the circulation is most likely to be impeded. The circulation in the tips of the toes is carefully watched, but if the windows have been cut in the plaster there is little risk of serious obstruction, although to the uninitiated such an event must appear inevitable. As a rule, there is little pain or swelling after the operation, and what pain there is arises from the pressure of an ill-fitting bandage, which should be cut away over the painful spot.

In putting on a bandage it is very useful to place next the flannel bandage and under the sole either a flat piece of brass, with the flange turned up on the inside and outside, as designed by my colleague, Mr. E. Muirhead Little (Fig. 220), or a thin foot-plate of wood may be used. The former is better, as it can be held

tearing of the ligaments and alteration in position of the bones which must take place in this form of reduction tuberculosis is so seldom seen.

while the plaster is setting, and obviates the risk of inward twisting of the foot (Fig. 223).

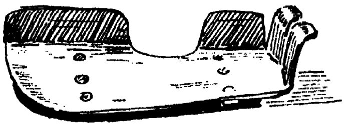


FIG. 220.—E. Muirhead Little's Shoe for maintaining the Corrected Position while the plaster of Paris is setting. The Flanges are on the Inner Side of the Foot. The Shoe is now made of Galvanised Steel.

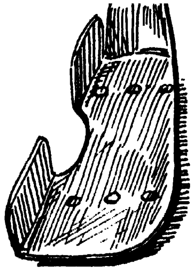


FIG. 221.—View of the same from above.

Early Functional Use.—So soon as the pain and discomfort have passed off, which will be in twenty-four to forty-eight hours, the

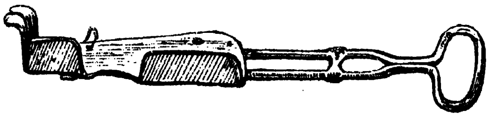


FIG. 222.—A Side View of the same, with the Controlling Handle in position. It fits into two Steel Loops on the under surface of the shoe, and can be readily withdrawn when the plaster has set.

patient begins to use the foot, and, in order to equalise the weight-bearing surface, wedges of wood or of cork may be attached to the

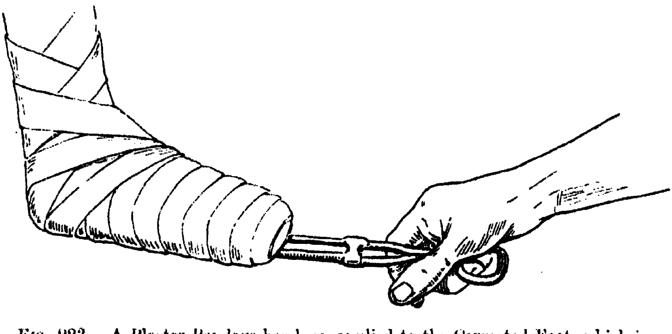


FIG. 223.—A Plaster Bandage has been applied to the Corrected Foot, which is held in position by the shoe and handle.

sole of the plaster bandage. A slipper is used indoors and an over-shoe for out of doors.

At the end of a month the plaster has become loose and requires renewal. On taking off the bandage, the foot is capable of over-correction in all directions, but it is far from consolidated into its normal position. A second bandage is applied in the over-corrected position. The patient gets about as before, and he is taught to walk with the limbs everted and somewhat abducted, so as to call into play muscles which have hitherto not been much used. The second bandage is left on for two to four months, and then a walking apparatus or brace is applied, extending to the thigh, and so fitted into the boot that eversion is maintained. Plantar flexion is prevented by a right-angled equinus stop at the ankle, and a wedge is placed on the outer side of the sole and heel of the boot, so as to keep the foot everted and abducted.

We are now at the stage of support and active treatment. The muscles of the leg and foot, particularly the abductors and evertors, are massaged twice daily, and the foot is passively manipulated into the over-corrected position. At the same time the patient is encouraged to carry out active movements of abduction and eversion. When it is evident that the muscles have acquired sufficient power for this purpose the case is practically cured.

Supervision.—For a long period, however, an eye must be kept upon the patient for signs of relapse. This is a simple matter, but often deemed by the parents unnecessary, the result being that the treatment has to be commenced all over again.

(*b*) *Julius Wolff's Method for the Correction of Confirmed Club-Foot.*—Wolff remarks[1] "that the ideal aim in the treatment is not only to correct the deformed foot, but to lead back to the normal condition all the associated abnormalities." The only way to do this is by means of "function." We should overcome the resistance to placing the foot in a normal position, either at once or in rapid stages. The object should not be merely a pulling into shape, but so redressing the foot as to get correct static relationship, and then "*Transformationskraft*" does the rest. His method consists in preliminary tenotomies in severe cases, then manual *Redressment*, fixing the foot in gypsum. This process is repeated every three to five days, and in about three weeks all resistance is quite overcome. The number of stages is lessened if König's manipulations[2] are used. The object of carrying out the operation in numerous stages is to avoid severe injury to the foot. The correction is continued until a correct plantigrade method of

[1] *Club-Foot*, p. 112. [2] *Beiträge*, *Centralbl. f. Chir.*, 25th Nov. 1890.

progression is possible. This takes some weeks, and the patient then walks about as much as possible in the bandage until *Transformationskraft*[1] has done its work. This takes from some months to a year.

The method is described by Freiberg.[2] The patient is anæsthetised, and the deformity is reduced by the hand so far as possible. The foot is held in the improved position by strips of adhesive plaster passing from the dorsal surface of the inner border of the foot under the sole, and up to the outer aspect of the leg. The leg and foot are then covered with cotton wool from the tuberosity of the tibia to the tips of the toes, and a plaster bandage is applied. As the plaster is hardening, the position of the foot is still further improved by pressing the heel downward and the fore-foot upwards and outwards. Two fenestra are cut in the plaster at the points of greatest pressure, one over the external surface of the ankle, and the other over the internal surface of the great toe. If tenotomy is necessary it is usually performed as a preliminary operation several days before forcible correction.

On the third or fourth day after the operation, a wedge-shaped section is cut from the bandage on the outer side of the ankle joint, and a linear division is made around the inner side of the ankle so that the leg and the foot parts of the bandage are separated.

The leg being held firmly, the foot is forced outwards and upwards to the extent that the wedge-shaped opening in the plaster allows, and the two sections are then united by a plaster bandage. At intervals of some days larger wedges are removed, and the manipulation is repeated until the patient stands with the foot everted, abducted, and dorsiflexed. In bad cases it is advisable to remove the plaster altogether at the end of five days, repeating the manipulation and refixing the foot, and this is again carried out until it is in good position. Then the plaster bandage is covered with strips of pine shavings, secured by a crinoline bandage painted with glue. After this is set, the heel is covered with a thin silicate bandage, a shoe is fitted to the foot, and the patient is encouraged to walk. This form of dressing is used until transformation of the deformed part is complete.

The first stage, then, is the stage of primary correction, and occupies a week to a month. The second stage is that of support and

[1] By this is meant influence of function in the right direction in remodelling deformed bones into normal shapes.

[2] *Medical News*, 29th Oct. 1892.

transformation; the third stage comprises massage and exercises, with general supervision.

Both these methods, namely, those of Wolff and that now currently described as Lorenz's, have been the subject of much criticism. Thus Kocher maintains that the severer cases of club-foot are capable of gradual correction only, and rapid correction must lead to tearing of the capsule at Chopart's joint, or fracture of the bones. Wolff, however, says that the foot as a whole gives, and not Chopart's joint especially. Injuries arise when osteoclasis is done, but are not traceable to forcible manipulation only. Volkmann criticised Wolff and failed to see how the method which had been used unsuccessfully hundreds of times by others should in Wolff's hands give good results. Wolff replied to him by showing a young man aged nineteen of the severest congenital type. In twenty-three

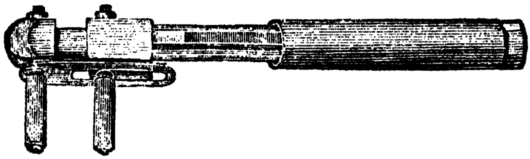


FIG. 224.—The H. O. Thomas Wrench (Robert Jones).

days after the commencement of treatment the patient was walking with the foot in the over-corrected position.

The relapses are due to the surgeon being content with partial correction. It is quite certain that the club-foot fixed in calcaneo-valgus never relapses if sufficient care is taken to restore the muscular balance.

II. **Reduction by Wrenching.**—A very large number of wrenches and osteoclasts have been devised. The best form for treatment is the H. O. Thomas wrench (Fig. 224). I have modified this in the following directions:—The wrench as a whole is larger and stronger. The metal of the arms is of an oval shape from side to side, so as to afford a larger surface of contact with the foot, and the upper arm, instead of being straight, is curved, so as to fit more closely to the convex surface of the dorsum or the convex outer edge of the foot (Fig. 225).

W. Thomas of Birmingham, arguing that force cannot be applied satisfactorily from the side, as in the H. O. Thomas wrench, has also designed a wrench (Fig. 226). While it has the advantage claimed by its designer, its disadvantage is that when it fits closely

it constricts the foot completely, and may cause interference with the circulation.

Some other useful wrenches are Vincent's modification of Robin-Mollière's tarsoclast, which I have seen used very effectively at

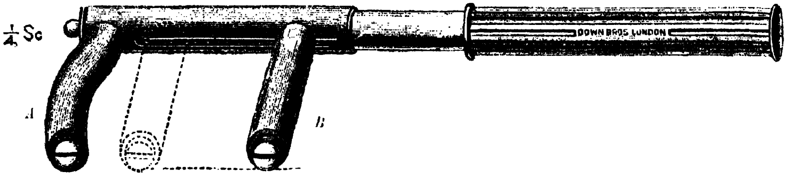


FIG. 225.—The author's modification of H. O. Thomas' Club-Foot Wrench. The apparatus is heavier and more powerful than the original. The Upper Arm is curved so as to fit the Dorsum of the Foot, and both arms A and B are oval on section (Down Bros. Catalogue).

l'Hôpital de la Charité at Lyons. Lorenz has designed and uses a wrench. Most of the other wrenches are complicated.[1]

The method of using the H. O. Thomas wrench or the author's modification of it, is as follows:[2]—After preliminary tenotomy and syndesmotomy the wrench is applied. For the inversion deformity

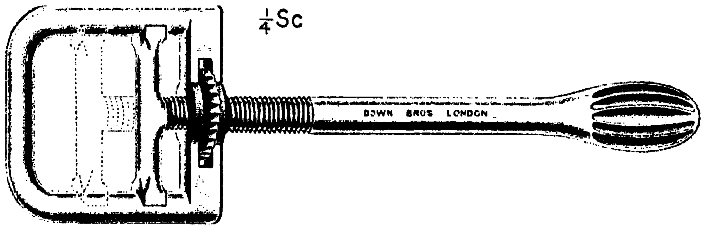


FIG. 226.—W. Thomas' Wrench. The advantage claimed is that the application of force is exactly opposite the point where it is required (Down Bros. Catalogue).

of varus, the pins of the wrench should grasp the foot on the inner side and be sufficiently tightened to prevent all danger of slipping. The upper pin should be against the astragalus (Fig. 227), and the foot forcibly rotated outward, counter-pressure being applied by the operator's hand, which is placed against the lower end of the fibula.

For the equinus deformity the position of the wrench is the same, but the handle should be made to work in the flexion axis of the ankle-joint (Fig. 228). To correct the adduction deformity at the

[1] Full descriptions, with figures, of the various forms of tarsoclasts are found in the *Traité de chirurgie orthopédique* (Rédard), and in *Deformities of the Human Foot* (Walsham and Hughes).

[2] Personal communication from Mr. Robert Jones.

mid-tarsal joint the upper end should be placed against the cuboid, and the lower behind the first metatarso-phalangeal joint (Fig. 229). The

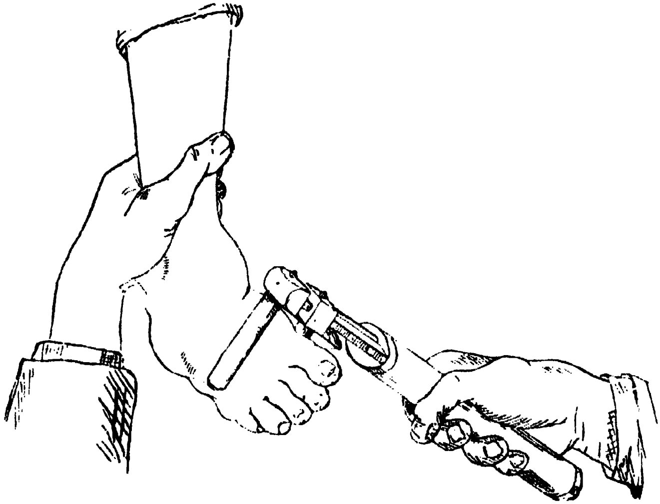


FIG. 227.—Reduction of the Varus Part of the Deformity by the H. O. Thomas Wrench (Robert Jones).

structures on the inner side should then be stretched. The twisting and bending are done quickly and forcibly, and the foot is immedi-

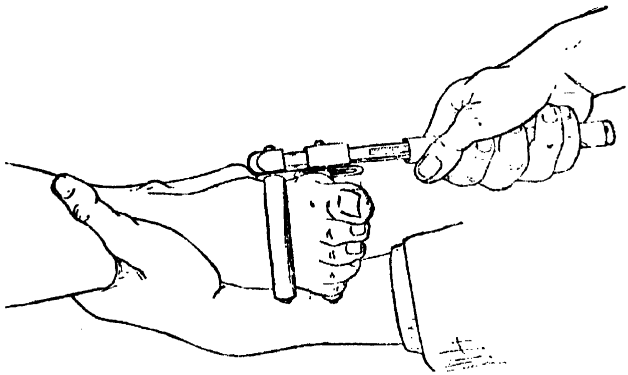


FIG. 228.—Reduction of the Equinus Portion of the Deformity (Robert Jones).

ately released. Holding the foot in the bite of the wrench too long may result in a pressure sore.[1] The keynote of treatment consists in the extent to which the stretching is carried. It should be to

[1] This can be obviated by placing a strip of rubber or a layer of wet cloth between the pins and the foot.

such a degree that the foot is temporarily paralysed, and lies limp in the hand. A retention splint is then applied. After two or more days, depending on the degree of the deformity and the severity of the wrenching, resiliency of the foot begins to return, and the wrenching is repeated. To anticipate the inward rotation of the tibia and fibula, one hand holds the leg below the knee and fixes it, while the other grasps it above the ankle, and attempts by a twisting movement to overcome the rotation of the tibia. This manœuvre should be practised frequently. The foot in every case must be over-corrected.

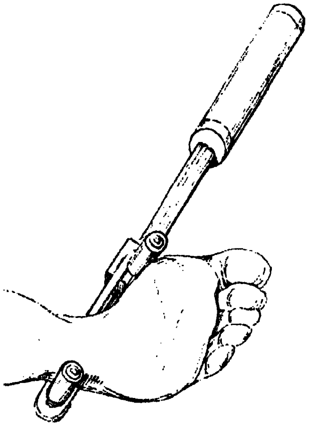


FIG. 229.—Overcoming the Adduction of the Foot at the Medio-Tarsal Joint (Robert Jones).

Dangers of Wrenches.—Accidents have happened from their use. These remarks apply, not so much to the H. O. Thomas, as to the more formidable varieties of wrench. Tearing of the skin has occurred, particularly across the oblique crease on the inner side of the sole of the foot. Sloughing of the skin from prolonged pressure of the wrench has been produced. Gangrene follows, not from the wrenching, but from the pressure of the plaster bandages, allowance not having been made for the subsequent swelling of the foot.[1] Inexperienced and careless surgeons may separate the epiphysis or fracture the bones of the leg. The latter event is not so serious, and in some cases, if excessive inward rotation of the leg is present, the bones are fractured of set purpose to permit the reduction of inversion of the limb.

Wrenching is not called for in the less degrees of club-foot, but in neglected and confirmed cases it is of great value. After the operation either retention-splints or plaster may be used. In the latter event the circulation must be carefully watched.

III. **Subcutaneous Division of Resistant Structures, followed by Manipulation or Wrenching.**—We have already carefully enumerated those structures which oppose reduction. All these are

[1] Vincent of Lyons states that he has had to deplore one case of gangrene from this cause (pamphlet).

divided and the wound allowed to heal, and in a few days the foot forced, either by the hand or by wrenches, into an over-corrected position. This method is suitable for those cases in which the deformity is mainly focused about the medio-tarsal joint, but not for those in which it is more equally distributed over all structures of the foot.

IV. **Phelps' Operation or Open Division of the Resistant Structures.**—This operation is more frequently done in America than in this country, and many good results are said to have been obtained by it. The nature of the operation is an open incision through the contracted structures in the sole of the foot, combined with forcible rectification of the deformity. It is therefore manifest that when the deformity is mainly bony the operation is not likely to afford complete relief. Fairly good functional use of the foot often follows, but relapses are frequent, and the contraction of the scar often causes considerable trouble. It is not adapted for very severe cases, and, further, it in no way helps to overcome what is so persistent a feature of relapsed cases, namely, the absence of power of complete dorsiflexion at the ankle. It can never be an operation of general utility, but is only available for very selected cases. By his subsequent modifications, which comprise operations on the bones, the originator appears to the writer to have acknowledged the insufficiency of his first procedure. Phelps often found it necessary to divide the neck of the astragalus and to chisel through the cuboid bone before he could obtain permanent rectification.

It is difficult to obtain a true estimate of the value of the operation. It appears, however, that when done for mild cases it is unnecessary, and that good results might have been achieved by simpler methods; also that when done for bony deformity it has not been successful. The operation has never impressed the author as scientific, skilful, or satisfactory. The stages of the operation are as follows:—

An incision is made from the tip of the internal malleolus to the middle of the sole of the foot, and all the structures, except the internal plantar artery and nerve, are divided right down to the bone. These structures include the tibialis anticus and posticus, the plantar fascia, the abductor pollicis, the flexor brevis digitorum, the flexor longus digitorum, the whole of the deltoid ligament, the astragalo-scaphoid capsule, and occasionally the tendon of the peroneus longus. As the tissues are identified and divided, repeated attempts are made to correct the foot. Finally, the tendo Achillis and

posterior ligament of the ankle joint are severed. Much blood is often lost at the operation, and it is advisable to use an Esmarch's bandage. It is not essential to preserve the internal plantar artery and nerve, but it is better to do so if possible.

After the operation a large gaping wound is left on the inside of the foot. When all hæmorrhage has been stopped, this is covered with green protective and the wound dressed with gauze. The foot being held in a corrected position, a plaster bandage is applied, and the limb is elevated. The large gaping wound closes by granulation in from one to three months. The plaster bandages require frequent changes.

A difficulty in the after-treatment is the tendency for the edges of the skin to become inverted and to form the shelving sides of a deep depression. Attempts have been made by Mr. Arbuthnot Lane,[1] Mr. T. H. Kellock,[2] and Mr. Muirhead Little to obviate this by applying a large skin graft over the wound, or by sliding a flap of skin from the outer side of the foot until it can be adjusted over the wound. Thus comparatively rapid healing has been secured, and re-contraction can be avoided. Bradford and Lovett[3] advise that the incision should be made as follows:—From the tip of the internal malleolus to the under surface of the first metatarsal bone, and, if required, a cross incision across the sole of the foot from the middle of the long incision, but it is desirable to avoid this if possible. Or, a triangular incision with its apex towards the ankle, instead of cross cutting of the skin and fascia, is equally efficient, and diminishes the gap after correcting the foot.[4]

The later modifications of the operation consist of osteotomy of the neck of the astragalus, or the removal of a cuneiform section from the os calcis. If these additional procedures are called for, the same result can be obtained by subcutaneous section of the structures on the inner side of the foot and section of the bones, thus rendering the large open wound on the inner side of the foot entirely unnecessary.[5]

1 *Lancet*, 18th August 1893.

2 *Ibid.* 30th March 1895.

3 *Orthopedic Surgery*, 3rd edit. p. 537.

4 Jonas, *Annals of Surgery*, April 1897, p. 449.

5 The literature of Phelps' operation is extensive. Some of the references are as follows:—*Phelps' Method of Treating Club-Foot*, A. Philipson; *Arch. f. klin. Chir.* Bd. xxxii. S. 989; and *Annals of Surg.* vol. viii. p. 459; G. Krauss, *Deut. Zeitschr. f. klin. Chir.* Bd. xxvii. Hefte 3, 4; and *Ann. of Surg.* vol. ix. p. 306; V. Mackenzie, *Trans. Am. Orth. Ass.* vol. iv. p. 48; Willard, *T.A.O.A.* vol. v. p. 225; Phelps, *T.A.O.A.* vol. v. p. 232.

V. **Operations on the Bones.**—These are classified according as they are designed for the relief of:—(1) Twisting inwards of the foot, mainly situated about the medio-tarsal joint; (2) Loss of dorsiflexion at the ankle; (3) Conditions (1) and (2) combined; (4) Tilting outward of the upper surface of the os calcis.

1. For *inward twist of the foot.* We have already, in describing Phelps' operation, alluded to osteotomy of the neck of the astragalus. We shall speak of (*a*) Astragalectomy, partial or entire; (*b*) Tarsectomy, either wedge-shaped, or simple removal of the anterior part of the os calcis for this type of deformity.

2. For *loss of dorsiflexion at the ankle.* The operations usually practised for this are (*a*) Astragalectomy, either partial or complete; (*b*) Separating the lower end of the fibula from the tibia, so as to widen the transverse axis of the ankle joint.

3. For *conditions 1 and 2 combined*, or the severe forms of rigid and neglected club-foot. Cases are often met with, which require removal of the astragalus with subcutaneous section of the structures on the inner side of the foot. This operation generally suffices to overcome the deformity, both at the ankle and medio-tarsal joint. In the worst cases astragalectomy must be combined with cuneiform tarsectomy.

4. When *the ball-shaped heel* is present and the os calcis is tilted in the way above mentioned, resection of the calcaneo-astragaloid joint is called for.

We may infer from the preceding paragraphs the indications for the various forms of operations upon the bones.

Astragalectomy.—This operation was first performed by the late Mr. Lund of Manchester, and of all the operations on the bones is that which is most generally useful. The simplest method of removing the bone is to make an incision commencing about two inches above the tip of the external malleolus downwards and forwards to the base of the fifth metatarsal bone, cutting at once down to the bones. No important structures are divided. The soft parts are rapidly reflected over the dorsum of the foot, and the astragalus is exposed. Some difficulty is often experienced in determining its outlines. It is sometimes so distorted that the normal guides are lost (p. 270). Very frequently there is a large square external non-articular surface tailing off anteriorly into a prominent tubercle, the prefibular tubercle, situated in front of the external malleolus (p. 270). The bone itself is also displaced downward and forward, and therefore the ankle joint appears to be

farther up the limb than usual. This deceptive appearance often causes difficulty, and we have known the scaphoid to be excised in the belief that it was part of the astragalus. After the soft tissues have been reflected from the bones, the position of the ankle joint is identified, and then the astragalo-scaphoid capsule is cut through. Much time is saved in removing the astragalus in adults if the neck is completely sawn through, and the bone removed in two pieces, the anterior part being taken away first. The chief difficulty in removing the posterior part is on the inner side, but the bone should be seized with a strong pair of forceps and twisted on its attachments, which are thus made tense, and divided with a knife close to the bone. If the foot does not come into good position, that is, if inversion remains, the anterior part of the os calcis should be excised. In order to remedy the inversion deformity the whole of the astragalus must be removed. Partial operations, such as ablation of the head and neck, are insufficient and are frequently followed by relapse.

Before undertaking astragalectomy all the contraction of the soft tissues should be treated. Astragalectomy is not indicated as a primary operation in childhood. It is to be reserved for relapsed and confirmed club-foot.

2. *Loss of Dorsiflexion at the Ankle.*—This is the most persistent of all forms of residual deformity after the treatment of club-foot by the less severe measures. It is also the most usual cause of relapse. We have repeatedly said that the chief difficulty in a complete reduction of club-foot is the impossibility of forcing, even by wrenching, the broad anterior portion of the upper articular surface of the astragalus backward and upward, so as to make it fit into the ankle joint. This difficulty is overcome, either by separating the fibula from the tibia, so as to permit the head of the bone to be forced back, or by partial or complete astragalectomy. In the less severe degrees of plantar flexion the mortise of the ankle joint may be widened by separating the bones. After division of the tendo Achillis and thorough section of the posterior ligaments, an incision is made over the anterior aspect of the anterior tibio-fibular articulation, and the ligaments are completely divided. A chisel is then inserted, and the bones prised apart; the astragalus is replaced, and the wound closed. If it is found that this is insufficient owing to the resistance of the interosseous ligament, the incision can be continued downwards and outwards towards the base of the fifth metatarsal bone as a preliminary to astragalectomy.

In some cases partial, in others complete, astragalectomy suffices:

and I am accustomed to make this distinction between them. If the foot itself is entirely straight with the leg, and the deformity is only at the ankle joint, partial removal suffices. But if inversion is combined with absence of dorsiflexion the whole bone must be removed.

In partial removal the upper half of the bone is taken away, care being taken that the section is somewhat oblique downwards and forwards, so as to prevent locking of the remainder of the astragalus against the anterior edge of the articular surface of the tibia. Extended experience has led me to believe that the shape of the foot is easier to maintain in these cases after partial than after entire removal. Free movement at the ankle must not be sacrificed to æsthetic considerations.

After complete astragalectomy the greatest care should be taken to over-correct the foot and to keep it so for a long time. The patient then walks with a functionally perfect foot, and beyond the existence of some slight shortening its movements are excellent. As the cartilage on the tibia and fibula is not interfered with there is no likelihood of ankylosis at the ankle.

3. When, in severe cases, *inversion of the front part of the foot is combined with limitation of upward movement at the ankle*, astragalectomy is indicated. In still severer cases it is necessary to perform a cuneiform tarsectomy as well. Before doing this, all the structures on the inner side of the foot are lengthened, as much as possible, by tenotomy, wrenching, and the use of the plaster of Paris bandage or Scarpa's shoe, and it is only when these are found ineffective that tarsectomy should be performed. It should never be done in young children, and is to be reserved as an operation for confirmed and neglected deformity.

While tarsectomy is a very useful operation, yet it is in a sense a confession of failure. In club-foot, the causes of the deformity are situated entirely in the inner segment of the foot, and, as we know, rational treatment consists in lengthening this. To leave this still contracted more or less, and then to shorten the outer lengthened and overgrown segment of the foot in order to compensate, does not seem a very rational procedure, but in practice it works well. A great deal has been written on tarsectomy, and heated discussions have taken place, but we must take facts as they are. If we cannot lengthen the inner side of the foot we are forced to shorten the outer.

Tarsectomy.—The operation is a simple one. An incision is

made from the tip of the external malleolus to the base of the fifth metatarsal bone, and the soft parts are rapidly raised from the dorsum. The peronei tendons are preserved if possible; if not, they are divided, turned aside, and after the bone has been removed united with silk. The surgeon then determines the size of the wedge to be removed, and working from the dorsum with a chisel, cuts out a sufficient portion of the bones about the medio-tarsal joint to enable him to restore the foot to a straight position. The operation is done irrespective of the joints, the immediate object being to restore the foot to the straight line. The wounds are then closed, and the foot is retained in proper position until they are healed. Then for several months the foot is kept in plaster bandages.

On the whole, in selected cases, the results are quite satisfactory. There are, however, some risks involved. Unless rigid aseptic precautions are taken, suppuration follows. The cleansing of the skin should be very thorough. In old-standing cases the corns and thickened skin require very careful attention. They should be soaked with liquor potassæ, and the part then sterilised with ether-soap, turpentine, and methylated spirit, and finally compressed with 1 in 2000 biniodide of mercury solution. This process may have to be repeated four or five times before the skin is sterile.

As to the appearance and utility of the foot after the operation, the shape and outline of the foot are often perfect, but its natural elasticity is somewhat diminished. Still the patient can often eventually walk without fatigue for many miles.

4. *Operations for the Ball-like or In-twisted Heel.*—In some instances it is sufficient to divide the ligaments connecting the astragalus and os calcis. This is best done from the inner side. An incision is made horizontally along the line of the calcaneo-astragaloid joint down to the deep fascia. A periosteal elevator is then inserted beneath the posterior tibial tendons, the posterior tibial artery and nerve, and they are lifted away from the bone. Working beneath them with a sharp narrow-bladed chisel all the ligaments are completely divided, including the interosseous and the external ligament, and the tendo Achillis is severed, and then the heel can be brought easily outwards. If, on account of the alterations in the shape of the bones, this cannot be done, portions of them are removed until the natural position of the heel is restored.[1]

[1] LITERATURE OF TARSECTOMY.—Some references are: Little, *Practical Observations on the Treatment of Club-Foot*, 3rd ed. p. 305; Verbelzi, *Centralbl. f. Chir.* No. xxiv.

Amputation of a talipedic foot is very rarely necessary. It is justifiable (1) when the previous treatment has been tried and failed; (2) When the patient is unable to give the time necessary for prolonged treatment; (3) If the whole foot is disorganised by suppurating corns and bursæ, and necrosis of some of the bones; (4) In some excessively painful forms of talipes.

OTHER VARIETIES OF CONGENITAL TALIPES

TALIPES EQUINUS

Synonyms—French, *Pied bot équin;* German, *Pferdefuss, Spitzfuss.*

Occurrence.—Talipes equinus is one of the rare congenital deformities. Little recorded 2 cases and Adams, 3 cases. Whitman's statistics show that of 2103 cases of congenital talipes only 49 were equinus. Of 311 congenital cases of my own, 14 were examples of equinus.

In the congenital variety of talipes equinus the heel is raised and the arch deepened; the foot is in a direct line with the leg, and there is no weakness about the medio-tarsal joint. This contrasts with the condition which prevails in paralytic cases, where the front part of the foot is dropped so that the head of the astragalus and upper surface of the scaphoid are very prominent.

In congenital equinus the deformity is as a rule slight, and in some cases it can be overcome by simple manipulation or by using a malleable iron splint bent to a right angle and applied to the back of the leg and sole of the foot. When these measures are not sufficient, tenotomy of the tendo Achillis, succeeded by the wearing of a varus shoe or a rectangular tin-shoe with quadrant at the ankle, effects a cure.

1877; Davy, *Lancet*, Feb. 14, 1888, and Oct. 14, 1893, p. 921; Davies-Colley, *Med. Chir. Trans.* 2nd series, vol. xliii., 1877; König, *Centralbl. f. Chir.*, 1880, No. xiii.; Rupprecht, *ibid.*, March 13, 1880; Mensel, *ibid.* No. xi., 1880; Hartley, "Operative Treatment of Club-Foot," *Ann. of Surg.*, March 1894; De F. Willard, *Trans. of Orth. Assoc.* vol. v. p. 225; Bradford, *ibid.* vol. i. p. 89; A. C. Ramsay, *Ann. of Surg.* vol. xii. p. 423; Gibney, *Ann. of Surg.* vol. xi. p. 334; Ewen, *B.M.J.*, Oct. 17, 1891, p. 842.

CONGENITAL TALIPES CALCANEUS

Synonyms—French, *Pied bot talus*; German, *Hackenfuss*.

In the congenital form the deformity is rare. Bradford and Lovett[1] have met with 28 cases in 1660 of congenital deformity of the foot. Whitman[2] has noted 47 in 2103, and the writer has seen 6 in 311 cases. William Adams said that "it was the rarest of all forms of congenital club-foot"; the collection of statistics, however, now quoted disproves this statement.

Aspect of the Foot in Congenital Calcaneus.—The foot is perfectly normal in shape, and is dorsiflexed upon the leg and held by shortening of the extensor muscles, at an acute angle. There is no increased arch to the foot. Indeed, if the cases are seen and treated before walking is commenced, the sole of the foot is flat. Occasionally, slight deviation of the foot to one side or the other occurs, and the deformity is either *calcaneo-varus* or *calcaneo-valgus*; sometimes, transverse folds are seen on the dorsum of the foot.

The complications of congenital calcaneus are genu recurvatum, varus of the opposite foot, complete or partial absence of the fibula, tibia, tarsal bones, or deficient and defective toes. Spina bifida, hydrocephalus, and cleft palate are sometimes associated with the deformity.

There is little or no displacement or alteration of the bones of the foot. The anterior ligaments of the ankle joint are shortened, and the posterior are lengthened.[3] The muscles contracted are the extensors of the toes. Lonsdale[4] has described a rare complication of this form of club-foot, namely, rigidity of the knees in an extended position with flexion of the thighs, and I have met with this condition in two cases of congenital cerebral diplegia.

The **prognosis** is good as a rule, and the cases are readily cured except when absence of bone complicates the deformity. In the

[1] *Orth. Surg.* 3rd ed. p. 551. [2] *Ibid.* p. 807.

[3] Dr. Griffiths of Cambridge (*B. Med. Journ.*, Dec. 30, 1893) describes a case of symmetrical talipes dorsalis in an acephalic fœtus. There was spina bifida extending from the skull to the mid-lumbar region. "The affected foot is sharply drawn upwards at the medio-tarsal joint so that its dorsum lies against the anterior surface of the leg, but the os calcis is horizontal." Dr. Griffiths' case is interesting, as it shows the evolution of congenital calcaneus. It is possible that the unbalanced action of the extensors acts first by hyper-extension of the medio-tarsal joint, and secondly at the ankle-joint, as development proceeds.

[4] *Lancet*, Sept. 1855.

uncomplicated cases, when the child commences to walk, the calf muscles acquire considerable power, pull up the heel, and bring the front part of the foot to the ground, so that the balance is maintained.

In the treatment of these cases it is sufficient in young infants to extend the foot daily several times and rub the posterior muscles; or the foot may be extended under an anæsthetic and placed in a retention apparatus. Probably the best form is a malleable iron splint which can be removed twice a day for rubbing the leg, and its angle altered as the case requires. Tenotomy of the extensors and plantar flexion of the foot in a tin-shoe with a quadrant, or retention in plaster of Paris are necessary if the child is over one year of age, and if the foot cannot be extended beyond the right angle under an anæsthetic.

The appearances in congenital present a marked contrast to those in paralytic calcaneus. In the former the deformity is at the ankle joint only; in the latter it is at both the ankle and medio-tarsal joint. In the former the muscles are not wasted, the leg is not cold, although the gait is awkward and slow. In paralytic calcaneus the heel strikes the ground first, and the fore-part of the foot flaps down afterwards.

Congenital Talipes Calcaneo-Valgus and Calcaneo-Varus

They are very unusual deformities. Whitman found calcaneo-valgus present in 87 of 2103 cases, and calcaneo-varus in 10 of 2103. We have met with calcaneo-valgus in 21 cases and calcaneo-varus in 2 cases of 311 congenital club-foot. They are therefore rare deformities.

In congenital talipes calcaneo-valgus the appearances of the foot are somewhat striking. The heel is depressed and the arch of the foot is lost. The outer border of the foot is raised, everted, and concave, and the inner border is lowered and convex. The portion of the foot anterior to the medio-tarsal joint is twisted so that the scaphoid, cuneiform, and the three inner metatarsal bones are pulled outward as a whole and depressed; while the cuboid and the two outer metatarsal bones are raised. The ligaments on the outer side of the foot are shortened, and those on the inner side lengthened. The muscles in a state of tension are the peronei and the extensor longus digitorum. And sometimes they require division.

In talipes calcaneo-varus the heel is depressed and the inner border of the foot is concave.

A peculiar twist in both these forms of congenital club-foot renders them somewhat difficult to treat. The main deformity of calcaneus often gives no trouble in treatment; but unless the associated varus and valgus are slight the foot does not present a very shapely appearance afterwards. Sufficient indications for treatment are given under the headings "Varus," "Valgus," and "Calcaneus." If the treatment be commenced quite early in infancy it is found that persistent massage, supplemented by retention apparatus, suffices to cure all the slighter grades of the deformity. In the more marked forms, tenotomy is called for during the first month after birth.

Congenital Talipes Varus

Varus is said to be a rare deformity. Whitman states that he found it existing in 89 out of 2103 cases of congenital deformity of the foot, and we have noted it in 44 of 311 cases. If all cases of slight pigeon-toe were included in the list, the number of varus cases would be greater. In some infants the great toe is greatly adducted and almost endowed with prehensile power. In the more marked forms of congenital talipes varus there is contraction of the inner bands of plantar fascia and of the muscles and tendons on the inner side of the foot.

The **treatment** of congenital varus has been detailed in Chapter X. dealing with equino-varus, so that it is only necessary to summarise it in this place.

1. In infants when the deformity can be nearly or entirely reduced by the pressure of the hand, manipulation and the use of retention apparatus are called for. Later on, walking instruments with a varus T-strap are necessary. If there is rotation inward of the bones of the limb, the brace should be carried up to the thigh or to the pelvis if inversion is persistent. A varus splint for night wear is advisable.

2. Cases which resist an attempt made by the hand to reduce the deformity require tenotomy of the tibialis anticus and posticus, with section of the plantar fascia and of the internal lateral ligaments of the ankle. The foot is then placed in a retention apparatus, either a malleable iron splint or plaster of Paris, and manipulated frequently. When the deformity is fully reduced a walking

apparatus of the same kind as in the first degree should be ordered.

3. Resistant cases can be reduced by tenotomy and fasciotomy, or by wrenching, either with the hand or the H. O. Thomas wrench.

4. Tenotomy and tarsectomy are called for when the patient is an adult, when the preceding treatment has failed after thorough trial, and when there remains no hope of reducing the deformity by less severe means.

Congenital Valgus

According to Whitman's statistics this deformity is second in order of frequency, namely, 144 cases of 2103, and according to Bradford and Lovett was met with in 123 of 1660. In the statistics published by Tamplin of 1780 deformed feet, 42 were examples of congenital valgus. In 17 both feet were affected. In 15 other cases, not included in the above 42, valgus was present in one foot and varus in the other. Of 311 cases of congenital club-foot coming under my notice, valgus existed in 11.

External Appearances of the Foot.—The arch is flattened, there is eversion of the sole, convexity of the inner and concavity of the outer border. In some cases the tendo Achillis is lengthened, and then calcaneo-valgus is present; if it is shortened, equino-valgus results.

William Adams noted shortening of the tendo Achillis as one of the ordinary conditions of valgus, especially in its congenital form, and with this observation Reeves agreed.

Association of Valgus with other Congenital Deformities.—The most frequent and easily recognised is partial or entire absence of the fibula. Numerous cases are noted by English and foreign surgeons. Thus Mr. L. A. Dunn[1] recorded a case in a child of eight years with a rudimentary fibula of about 1 inch long. The middle portion of the fibula appeared to fade away into the peronei muscles.

It is interesting that in these cases of deficiency of bone the foot is almost always in a position of equino-valgus, and that the tibia is much curved at the junction of the middle and lower third, also it is shortened. The convexity of the tibial curve looks either directly backward or forward. In the latter case a depression or scar is often seen, which is adherent to the bone. The cause both of this depression and of the curvature of the tibia is probably

[1] *Path. Soc. Trans.*, 1892, p. 272.

adhesion of an amniotic band. One or more toes are frequently absent and the muscles of the leg are atrophied. Malformation is generally unilateral. A case illustrating the co-existence of curvature of the tibia and absence of the fibula in congenital valgus came under my notice in 1892. The man had valgus of a pronounced type with complete absence of the fibula. The deformity was hereditary, several of his brothers and sisters, and his child, aged six months, being similarly afflicted.

Sometimes both bones of the leg are present, but the leg below the knee is very much shorter than the opposite limb, and there is always a sharp curvature forwards of the tibia and fibula at the lower third, the prominence of the convexity being 1 inch to 2 inches above the ankle joint, with a depression of the skin reaching to the bone. The shortening becomes more marked as growth proceeds, even to the extent of 5 or 6 inches, when adult age is reached.

The above forms of congenital valgus represent the more severe types. In the less severe examples the bones are normal, and congenital talipes valgus is simply an example of a congenitally weak foot or weak ankle.

Symptoms.—1. It is noticed that, after walking a short distance, the child cries on account of pain on the inner side of the foot.

2. There is little or no movement in the mid-tarsal joint, and the motion of the ankle is limited on account of the contraction of the tendo Achillis.

3. The child cannot invert its foot actively nor can it be inverted passively.

4. Eversion of the foot and also of the arch are very marked on standing.

Treatment.—(*a*) Where deficiency or absence of the fibula exists, passive movements and manipulation are of little use, and tenotomy is not of much service. I have been compelled on several occasions practically to arthrodese what is left of the ankle joint and wire or screw the parts together. But even then the deformity relapses, and in some cases amputation is preferable to the prolonged discomfort caused by recurrence of the valgus.

(*b*) In the slighter cases where no great deformity is present, section of the peronei and of the tendo Achillis with manipulation and retention apparatus effects a cure.

Congenital Talipes Equino-Valgus [1]

After the references which have been made to the frequent association of equinus and valgus and the separate descriptions given of these conditions, it is unnecessary to allude further to them except to say that some of them, which at first sight appear to be equino-valgus, are equinus and nothing else. The shortened tendo Achillis prevents the heel being brought to the ground

Fig. 230.—Front view of a case of Congenital Talipes Equino-Valgus in the right foot, and Intra-uterine Amputation of the front part of the left foot.

Fig. 231.—Back view of the patient in Fig. 231.

unless adduction or abduction take place at the ankle. Abduction is the position of rest and fatigue, so that equino-valgus occurs more easily than equino-varus.

Of the still rarer varieties of congenital club-foot such as equino-cavus, valgo-cavus, and pure cavus it is not necessary to speak at length. They are treated on appropriate lines as indicated in the chapters on acquired talipes.

Of 311 congenital cases, equino-valgus was seen twice and calcaneo-varus twice.

[1] Cf. Figs. 230, 231, where the right foot is in a state of extreme equino-valgus, with absence of the fifth toe. The left foot has been amputated *in utero*.

SECTION II

SOME NON-CONGENITAL DEFORMITIES OF THE EXTREMITIES

CHAPTER I

SOME NON-CONGENITAL AFFECTIONS OF THE WRIST AND HAND

Madelung's Wrist—Contracted Fingers—Ulnar Displacement of Fingers—Jerk-Finger—Mallet Finger—Base-ball Player's Finger—Lateral Deviation of the Fingers.

MADELUNG'S SPONTANEOUS SUBLUXATION OF THE WRIST

Synonyms—*Manus valga*—*Le Rachitisme tardif du poignée* (Duplay)—*Progressive Subluxation of the Wrist* (Kirmisson)—*Radius curvus.*

IN 1878, under the title of "*Die spontane Subluxation der Hand nach vorne,*" Madelung described a condition of the wrist, coming

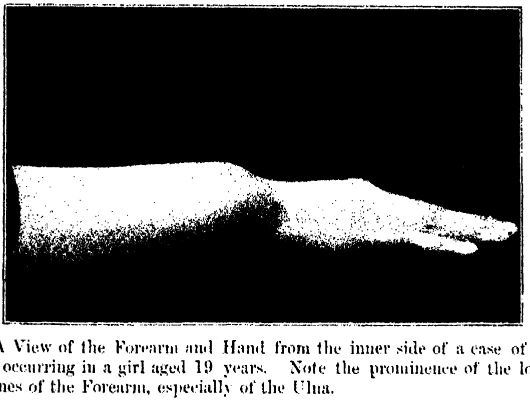


FIG. 232.—A View of the Forearm and Hand from the inner side of a case of Madelung's Wrist, occurring in a girl aged 19 years. Note the prominence of the lower ends of the Bones of the Forearm, especially of the Ulna.

on spontaneously, and not associated with injury or disease. Subsequent researches have established the fact that the affection is met with chiefly in women, and especially in washerwomen, from wringing clothes, and in pianists. It often starts about the period

of adolescence, it is steadily progressive, and at first it is accompanied by pain in the wrist, which is sometimes considerable. For a time the deformity is reducible, and in slight cases, if care be

FIG. 233.—The same, viewed from the outer side.

taken, spontaneous cure may ensue. On the other hand it often progresses to a permanent deformity, although the pain and some of the disability pass off in time. According to Kirmisson about two years elapse before the deformity is fully established.

In a well-marked case the following points may be observed.

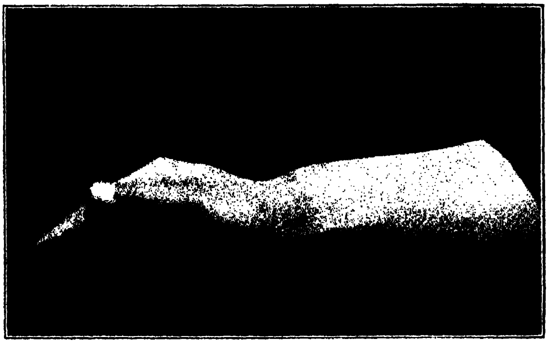


FIG. 234.—Another view from the outer side. The deformity is not so obvious from this side. The flexor tendons stand out in relief.

On viewing the wrist from its dorsal aspect, with the profile of the ulna displayed, the lower ends of the bones of the fore-arm are abnormally prominent, and particularly is this the case with the ulna (Fig. 232). On the palmar aspect the upper row of the carpus is prominent, particularly the pisiform bone, and the flexor tendons

stand out. When viewed from the radial side of the fore-arm, the deformity is not so obvious (Fig. 234); but when seen from the ulnar side the subluxation is very evident, and the wrist looks and is abnormally thick. If pressure be brought to bear on the ulnar prominence it can be reduced to the level of the radius; and immediately pressure is removed the ulna rises back to its previous position. This is due to laxity of the lower radio-ulnar articulation, and it can be shown by a skiagram that the bones are abnormally separated. An important point is that no curvature is present in the radial diaphysis.

The condition then is subluxation at the radio-ulnar joint, and a more or less complete luxation of the ulna from the carpus. It is generally stated that the lower end of the ulna is hypertrophied, but this is more apparent than real.

Another class of case is met with, presenting very much the same symptoms and clinical history, and in these the radial shaft is definitely curved. Cases of "radius curvus" are recorded by Kirmisson, Delbet, and others. They are rare, however, in adolescents. While the true Madelung's subluxation is to be regarded as an occupation-deformity, radius curvus may possibly be a manifestation of late rickets. By some observers Madelung's wrist is regarded as a rachitic manifestation, due to the ligamentous relaxation which accompanies that disease. This is a view, however, which does not commend itself to the author.

Treatment.—Massage, exercises, and electrical stimulation of the extensor muscles are advocated, so as to strengthen them and overcome the power of the flexors. Hoffa advised an arrangement by which the weaker extensor muscles are supplemented by elastic traction, a method which at first sight seems very likely to strengthen the flexors further by opposing them.

The author suggests that the simplest method is to keep the wrist over-extended on a suitable splint for a time, and massage the extensors.

Osteotomy has been successfully practised in certain instances of true Madelung's wrist. A curve has been formed in the radius so as to raise the level of the upper row of carpal bones. This procedure should be a last resource.

BIBLIOGRAPHY

ABADIE. De la luxation progressive du poignée chez l'adolescent. Rev d'orth., 1903, No. vi.

BARTHES. De la luxation progressive du poigné chez l'adolescent et chez l'adulte. Thèse de Paris, 1904.
BERGER and BANZET. Chir. orth. pp. 223-226.
DELBET. Leçons de clinique chirurgicale, 1899.
DESTOT et GALLOIS. Rev. de chir., 1898.
DUPLAY. Clinique chirurgicale de l'Hôtel-Dieu, 1900.
DUPLAY. Arch. gén. de méd., Avril 1885, and Gaz. des hôp., 1891.
DUPUYTREN. Clinique chirurgicale, tome iv.
GASNE. Des formations rachitiques tardives du poignée; subluxation de Madelung et radius curvus. Rev. d'orth., 1906, Nos. ii. and iii. This article gives an excellent summary of all the views.
GUERY. Rev. d'orth., 1898, p. 277.
JOACHIMSTAL. Handbuch der orth. Chir., Funftes Lieferung.
KIRMISSON. Difformités acquises. He also quotes Madelung, Arch. f. klin. Chir. xxii. 394.
MADELUNG. Die spontane Subluxation der Hand nach vorne. Verhandl. d. deutsch. Gesells. f. Chir. S. 259, Berl. 1878.
MALGAINE. Traité des fractures et des luxations, tome ii. p. 712.
POLSEN. Langenbeck's Arch., Bd. lxxv. Heft 2, S. 506. Cf. also Zeitschr. f. orth. Chir. Bd. xv. 11, 1905. Two cases are described here, both operated on by osteotomy.
SAUER. Die Madelung'sche Deformität des Handgelenks. Beiträge z. klin. Chir. Bd. xlviii. Heft 1. Also cf. Zeitschr. f. orth. Chir. xv. 2, 4, 1906.

ACQUIRED DEFORMITIES OF THE FINGERS

They may be classified as follows:—

1. Of cutaneous or cicatricial origin.
2. Of fascial origin, such as Dupuytren's contraction.
3. Due to affections of tendons.
   (*a*) Cicatricial contraction.
   (*b*) Jerk-finger.
   (*c*) Mallet finger.
4. Associated with muscular lesions.
   (*a*) After various inflammatory conditions.
   (*b*) Ischaemic contraction.
5. Of arthritic origin.
6. Of nerve origin.
   (*a*) Spasmodic.
   (*b*) Paralytic.

1. **Of Cutaneous or Cicatricial Origin.**—The fingers become severely deformed after burns, either due to fire or the action of acids. They may be flexed, extended, or laterally deviated and held rigidly in malposition by bands of cicatricial tissue, which distort them in a very horrible way, so that the hand is rendered nearly useless.

In those cases where the bands are clear and well-defined and limited in area, the writer has been successful in overcoming the deformity by operating thus: With a fine tenotomy knife a large number of incisions, not more than $\frac{1}{16}$ inch apart, are made across and through the cicatrix until healthy fat is reached, and into the openings fibrolysin (40 per cent of thiosinamin) is rubbed. No attempt is made at the time of operation to stretch the part, and it is placed on a malleable iron splint until the small incisions have healed. Then, by gradually altering the angle of the splint until it approximates to the straight line, and keeping the finger bound to it, the scar stretches. At the same time the fibrous tissue becomes supple and soft, and much, if not all of it, disappears. It is not advisable to stretch the finger at the time of operation, as the scar usually tears and fresh fibrous tissue is formed. In some cases, on account of the degree of contraction, it is necessary to repeat the operation, and the result is nearly always gratifying. This operation is naturally of little avail if the joints have become stiff from fibrous ankylosis, although an improvement can be effected by moving the parts under an anæsthetic, injecting fibrolysin around the joint, and assiduously massaging the part before carrying out the treatment already described. However desperate the case appears, it is remarkable what careful treatment, time, and patience will effect.

When, however, the scarring is very extensive and the fingers are bound together by cicatricial tissue, division of the bands, operations on the principles advocated for webbed fingers, and skin-grafting, should be combined. Finally, if a finger or fingers prove intractable, then the question of amputation is to be considered, the thumb, however, being spared.

Scarring about the wrist is a very troublesome matter to deal with, yet it can almost invariably be attacked with success on the above lines.

2. Dupuytren's contraction of the palmar fascia is dealt with under "The Affections of Fasciæ" (vol. i. sect. iv. chap. iv.).

3. Deformities of the fingers due to (*a*) Cicatricial contraction of tendons is treated in vol. i. sect. iv. chap. ii., where it is shown how much can be done for these serious deformities by plastic and restorative operations on the affected tendons.

JERK-, SNAP-, SPRING- OR TRIGGER-FINGER[1]

The description of the affection is that, if the patient closes all the fingers on the palm, on extension he finds that one remains shut. It can be extended by the other hand, when "it flies open like a knife-blade, with a snap" (Abbe).

Sometimes there is difficulty also in flexing the finger, which is accompanied by a small jerk. According to Reeves, the affection is generally seen in the thumb, and there is often a circumscribed swelling to be felt somewhere in the course of the tendon, and the obstruction is almost always near the metacarpo-phalangeal articulation. Abbe figures his cases, and the affection is seen to be in the ring and little fingers.

There is no doubt, however, that the middle finger is most often affected, then the ring finger and thumb, and the index and little fingers least of all—the right hand more often than the left. The rheumatic diathesis is present in 50 per cent of patients, and over-use and overstrain, or taking on unaccustomed manual labour, are responsible for its appearance. Women are more often the subjects of it than men. As a rule it begins between the ages of 30 and 40 years, but we have seen three congenital examples.

As to the pathology of the affection: there are many causes of jerk-finger. A thickening of the tendon or a narrowing of the tendon sheath, or osseo-fibrous groove, leads to interference with movement. The tendon is held until the muscular belly contracts with sufficient force to overcome the obstruction, when the tendon

[1] An excellent account of this affection is found in Mr. H. A. Reeves' *Bodily Deformities*, pp. 373-382. He gives numerous references to the subject, which may with advantage be reproduced here. They are—Notter, *Archives générales de méd.*, 1850, series iv. tome 24, p. 142; Busch, *Lehrbuch der Chir.* Bd. ii. p. 143; Hahn, "Ein Fall von federnden Finger," *Allg. med. Centralztg.*, 1874, No. 12; Menzel, "Über schnellenden (federnde) Finger," *Centralblatt f. Chirurgie*, 1874, No. 22; Berger, "Über schnellenden Finger," *Deutsche Zeitschr. für pract. Med.*, 1875, No. 7, 18; Zieber, "Über den sogen. schnellenden Finger," *Wien. med. Blätter*, Nos. 14-17, 1880; Vogt, *Die chirurg. Krankheiten der oben Extremitäten*, 1881; Felicke, *Über der schnellenden Finger*, 1881; Bernhardt, "Beitrag zur Lehre vom schnellenden Finger," *Centralblatt für Nervenkrankh.* No. 5, 1884. Mr. Reeves also briefly describes three cases on p. 375 of his work. Abbe, "Surgery of the Hand," *New York Med. Journ.*, 13th January 1894, also describes the affection, and gives illustrations of five cases. Other references are:—Duplay, "Doigt à ressort," *Gaz. des hôpitaux*, 1896, No. 44; Tillmann, "Der schnellende Finger," *Berl. klin. Wochenschr.*, 1900, No. 43; Payer, *Wien. klin. Wochenschr.*, 1903, No. 25; Hiller, *Zeitschr. f. orth. Chir.*, 1908, p. 48.

[2] The author has met with the affection from time to time in each finger, and it occurs more often in the middle finger.

moves with a jerk. Some of the causes of gripping of the tendon are bands of fibrous tissue, bridging across the sheath and narrowing it (Joachimstal); exostosis of the head of the metacarpal bone; partial division of a tendon, the retracted cut fibres giving rise to an enlargement (Haegler); new growths on the tendons, either simple fibromata, tuberculous, or malignant; ganglia on the flexor tendons[1] or on their sheaths.

On operating, or at an autopsy, the following conditions have been found:—A hernial protrusion of the synovial membrane (Leisrink), a thickening of the tendon as it passes through the osseo-fibrous groove (Wiessinger, Tubby), a constricting band across the tendon (Schönborn), circular thickening of the sheath (Duplay, Necker, Hiller) thinning of the flexor profundus tendon where it passes through the sublimis (Lüdeck), thickening of the sheath opposite the sesamoid bones of the thumb, associated with nodular thickening of the tendon here (Wiesinger, Blum), transverse fibres between the sesamoids (Notta, Nélaton), and, finally, some irregularity of cartilage in the joint itself (Vogt, König, Poirier).

Narrowing of the tendon sheath, with grooving and constriction of the tendon itself, or thickening of the vascular fringes of the vincula accessoria tendines from teno-synovitis seems the most frequent cause.

Treatment.—An attempt should be made to localise the spot where the jerk occurs. In the majority of cases it is at or near the metacarpo-phalangeal joint. In many instances a distinct nodule can be felt which may be either ganglionic or solid, and then an incision should be made and the nodule exposed and removed. If there should be no evidence forthcoming as to the cause, fixing the finger in a metal splint, with pressure on the spot where the movement of the tendon is arrested, may be tried before incision is resorted to. When all palliative treatment fails then the tendon must be exposed. If thickened it should be pared down. If the groove is narrowed it must be widened.

MALLET-FINGER

This affection, a rare one, is variously described as "mallet-finger," "drop-finger," "subcutaneous rupture of the extensor tendons," "drop-phalangette" (W. G. Stern). As to the cause,

[1] Cf. W. H. Battle, "Some Surgical Affections of the Hand, Flexor Ganglion," *Brit. Med. Jour.*, 8th April 1893, pp. 783, 784.

Morris[1] states that the deformity is not uncommon among men who engage in athletic sports. When the extensor tendons of the fingers are tense, a blow upon the end of a finger transmitting force in a direction which would ordinarily flex the finger, results in an injury to the extensor tendon, where it is attached to the dorsal surface of the last phalanx.[2] According to this writer the injury consists, not in a bodily separation of the tendon from its points of attachment, but rather in a thinning of the tendon on the proximal side of the principal point of attachment to the phalanx, and of the fibres which form the posterior ligament of the last phalangeal articulation; a few fibres are undoubtedly ruptured, but most of them slide away from each other, very much as the threads of a textile fabric separate when the fabric is violently stretched, but they are not torn.

FIG. 235.—Mallet- or Drop-Finger (after Abbe).

Abbe, who calls it "drop-finger," gives five cases, and all arose from slight causes.

We have met with eleven cases during the past nine years. Two of them are as follows:—

CASE 3.—*Mallet-Finger, treated by a Hyper-extension Splint; Recovery.*—Mrs. D., aged 35 years, was straightening out a sheet while "making" a bed. The hands were extended, and the third finger of the right hand caught in a fold of the sheet. It became immediately painful, and she noticed that the tip was dropped, and that she could not raise it. When she came under observation, the tissues at the root of the nail were swollen, tender, and later, looked bruised. The finger was placed on a malleable iron so arranged as to hyper-extend the last phalanx. In

[1] Some references to this subject are—Abbe, *N.Y. Med. Jour.*, 13th Jan. 1894, *The Surgery of the Hand*, being the affection described under the title of "Drop-Finger"; R. T. Morris, "Mallet-Finger," *Medical News*, 19th Sept. 1893; M. E. Schwartz, *Arch. générales de méd.*, May 1891, under the title of "Subcutaneous Rupture of the Extensor Tendons of Fingers," quoted in *Brit. Med. Jour.*, Supp., 20th June 1891; W. G. Stern, "Drop Phalangette," *Amer. Jour. Orth. Surg.*, Feb. 1909, vol. vi. 3, p. 484. He quotes five cases.

[2] Abbe deduces "from the experience gained at an operation on one of his cases that the force which produces this deformity is not one which is directed perpendicularly to the dorsum of the finger, but rather one that comes to one side or the other, just as one would go about it to tear a narrow strip of rather tough paper." In this case Abbe found that the capsule was stretched and the tendon lacerated only on the radial side, and not upon the ulnar side of the phalangette (Stern). One of the latter writer's cases "showed plain evidence that the force (a basket-ball) impinged upon the dorso-ulnar, and not the dorso-radial aspect of the distal phalanx."

fourteen days recovery had taken place, and she could use the finger well.

CASE 4.—*Mallet-Finger; Failure of Splint Treatment; Operation; Recovery.*—Mrs. T., aged 53 years, was pushing some chintz between the seat and the arm of a chair, when she felt a pain in the tip of the third right finger and found that it had dropped. A splint (not hyper-extended) was applied by her local medical man. After being under his care for a month she sought our advice, and a splint was put on so as to maintain the last phalanx in hyper-extension. However, after two months of this treatment the finger still dropped somewhat, and she wished for further treatment. An incision was made in the length of the phalanx on its dorsal surface, and the frayed-out extensor tendon was found. The fibres were gathered together, and re-inserted into the periosteum. The case did well, and the patient completely regained the use of the digit.

Abbe mentions that in base-ball players the reverse deformity to "drop-finger" is frequently seen. The last phalanx is violently dislocated backward, and cannot be replaced on account of the flexor tendons wrapping themselves round the head of the second phalanx, which slips through a buttonhole in the capsule.

Returning to the subject of mallet-finger, Schwartz gives three cases. In two the injury occurred to the little finger, and in one to the middle finger.

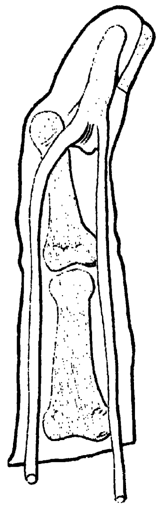


FIG. 236.—Base-ball Player's Finger. Dorsal Dislocation of the Last Phalanx (Abbe).

Symptoms.—Immediately after the occurrence of the injury to the tendon the last phalanx assumes a semi-flexed position. There are slight swelling and ecchymosis over the last interphalangeal joint, a circumscribed tender spot on the dorsum of the last phalanx, just below the joint, and inability of the patient to extend the last segment of the injured finger, all other movements being unimpeded.

The anatomy of the affection is either partial or complete tearing away of the attachment of the extensor tendon to the base of the last phalanx. As the result of experiments on the cadaver, Delbet was of opinion that the rupture was partial and not complete. In many cases the attachment of the extensor tendon is merely frayed out. If the case be left to itself, the last phalanx become

fixed in the flexed position, and the use of the injured finger is much impaired on account of the formation of adhesions in the joint.

Treatment.—In the first place the treatment should consist of the application of a malleable iron splint, bent up towards its tip, to the front of the finger, so as to keep the terminal phalanx fully hyper-extended. If, at the end of the three or four weeks the power of full extension has not returned, the surgeon should cut down and stitch together the divided ends of the tendon, or the tendon to the periosteum at the base of the last phalanx. Morris prefers to make a linear incision, to divide the tendon longitudinally into its two principal fasciculi, then sever each transversely on the proximal side of its thinnest part, and to advance each fasciculus to a point upon its own side of the finger near the base of the finger-nail. At this point the fasciculus is sutured to the under surface of the skin, with a suture which passes through the skin and is tied upon the outside. This is done because the tendon makes as good union with the soft parts as it would if sutured to the periosteum, and the hold is firmer. The finger-nail is sometimes temporarily lost, as the result of encroaching on its matrix. When the advanced fasciculi are sutured in place, the last phalanx is sometimes over-corrected, and hyper-extension at the first inter-phalangeal articulation is caused. This is merely temporary, and disappears in a few weeks, leaving a perfect finger.

Further References to Mallet-Finger

Taken from W. G. Stern's article "Drop Phalangette." Amer. Jour. Orth. Surg., February 1909, vol. vi. No. 3, p. 493.

Gurlt. Subcutaneous Injury to the Extensor Tendons. Eulenberg's Encyclopædia.

Nichols. Finger Deformities. Ref. Handbook of Medical Science.

Abbe. Drop-Finger. New York Med. Rec., July 22, 1899.

Kuhn. Brit. Med. Jour., 1896, p. 749.

Ritschl. Flexion of the Fingers from Splitting of the Extensor Tendon at the Knuckle. Münch. med. Wochenschr., 1907, No. 23.

Becker. Luxation of the Extensor Tendons of the Fingers. Münch. med. Wochenschr. No. 12, 1903.

Häberer. Idem. Deutsch. Zeitschr. f. Chir. Bd. 62, p. 191.

Schurmer. Idem. Centralbl. f. Chir., 1897, No. 31.

F. J. Cotton. Trigger-Finger. Amer. Jour. Orth. Surg., vol. viii., Feb. 1911, p. 587.

Other Acquired Deformities of the Hand

Amongst these there may be mentioned the contraction and ulnar displacement of the fingers occurring in osteo-arthritis

Fig. 237 is an example in a watchmaker, aged 23. This condition improved very considerably after taking arsenic and iodide of potassium, with frequent soaking of the hands in water containing bicarbonate of soda.

Another affection due to osteo-arthritis is Hutchinson's "last joint" arthritis. In these cases, mostly females, the base of the terminal phalanx is much enlarged and nodular, and the phalanx is deviated laterally.

A. Poncet[1] of Lyons has described a deformity of the hands

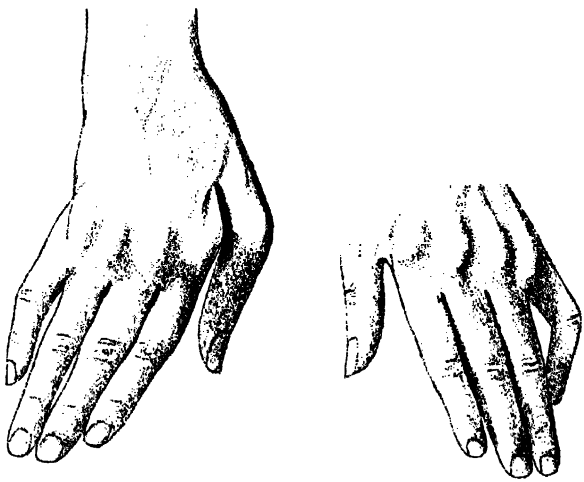


FIG. 237.—Displacement of the fingers towards the Ulnar Side in Arthritis Deformans.

which attacks glass-blowers. It is a severe hindrance to the usefulness of the hands, and has often been a cause of exemption from military service. The deformity consists of permanent flexion of the fingers upon the hand, the ring and the little fingers being more flexed than the middle and index. The thumb is free. The flexion is mainly at the first interphalangeal joint, and is said to be due to contraction of the flexor sublimis tendon. There is no thickening of the fascia nor contraction of the skin. The fingers deviate to the ulnar side.

The deformities arising from cerebral and spinal lesion will be considered in the chapters dealing with these matters.

[1] *Annals of Surg.* vol. viii. p. 151. Abstracted by C. R. B. Keetley.

Lateral Deviation of the Fingers

Mr. Reeves, in his work on *Bodily Deformities*, figures a case in which the second and third phalanges were laterally bent on the first, so as to form nearly a right angle. The condition appears to have been improved by the use of suitable instruments, and the present writer has operated for this deformity with some success.

Very marked examples of lateral deviation are often seen in cases of syndactylus,[1] and it has been described by various observers[2] in hands otherwise normal.

As already mentioned, the terms club finger, digitus varus, and valgus are used, but they are not free from objections. Fort suggests clinodactylus as a convenient designation.

The thumb is most frequently affected, and then the little finger. The deviation may be either at the metacarpo-phalangeal joint or interphalangeal, and may be toward or away from the median line of the hand. The deformity disappears on flexion.

We have not sufficient space here to discuss the causation, but the facts that heredity is marked and other abnormalities often coexist, should be noted.

As to the treatment, if improvement does not result from the use of mechanical appliances, cuneiform osteotomy may be considered, and in the case of a digit, other than the thumb, amputation may be called for.

[1] See skiagrams on pp. 61, 94, 95 of Klaussner's work, *Über Missbildungen der menschlichen Gliedmassen*, Wiesbaden, 1900.

[2] Fort, *loc. sup. cit.*; Annandale, *loc. cit.*; Robert, "Des vices congénitales des articulations," *These de concours*, 1851; Mounier, "Pouce-bot," *Soc. de méd. pract.*, June 18, 1891; Herzog, "Über angeborenen Deviationen der Fingerphalangen," *Münch. med. Wochenschr.*, 1892, No. xx.; Joachimstal, "Über angeborene seitliche Deviation der Fingerphalangen," *Zeitschr. f. orth. Chir.*, 1893, Bd. ii. S. 265: Delcourt, "Un Cas de doigt déviation" (double), *Journ. méd. de Bruxelles*, 1903, No. iii.; Witkower, "Über Hyperphalangie am Daumen, mit Valgus-Stellung der Endphalanx," *Inaug. Dissert.*, Berlin, 1902.

CHAPTER II

SOME ACQUIRED AFFECTIONS OF THE LEGS AND FEET

Genu Recurvatum—Acquired Displacement of Patella—Elongation of Ligamentum Patellæ—Slipping Patella—Enlargement of the Tubercle of the Tibia—Right-angled Contraction of the Tendo Achillis—Talipes (acquired), Arcuatus, Plantaris, Equinus, Calcaneus, Varus, Valgus, Equino-Valgus, Calcaneo-Valgus, Equino-Varus, Calcaneo-Varus—Hammer-Toes—Lateral Deviation of the Toes—Contracted Toes—Corns—Pain in the Soles of the Feet—Diffuse Painful Lipoma of the Foot—Bony Outgrowths on the Feet—Painful Heels—Achillodynia—Pain about the Base of the Fifth Metatarsal Bone—Fracture of Fifth Metatarsal Bone—Chilblains—Raynaud's Disease—Erythromelalgia—Dysbasia Angio-Sclerotica (Intermittent Limp).

GENU RECURVATUM

THE congenital form is described in the article on congenital dislocation of the knee (section i. chap. iv.). The acquired form is seen in rickets; and as a result of infantile paralysis or rupture of the crucial ligaments; for these conditions special treatment is demanded. The author's method of treating paralytic genu recurvatum is described in vol. ii. section xi.

ACQUIRED DISPLACEMENT OF THE PATELLA

The patella may be displaced upwards, outwards, or inwards. The causes are rickets, infantile paralysis, infantile hemiplegia and cerebral diplegia, and repeated inflammation of the synovial membrane of the knee-joint.

The upward displacement is almost invariably associated with infantile hemiplegia, and in a child aged six years and so affected, we have seen the patella occupying a position at least one inch higher than is normal. Altogether we have noted the upward displacement four times in this disease. The outward displacement is frequently seen in genu valgum. It is either partial or complete. In the former the patella is subluxated outwards rather

than displaced, a state of partially slipping patella. In the latter the patella slips out in flexion and lies on the outer side of the external condyle.

The **symptoms** vary. In some cases the disability is practically *nil*, but in other cases it is severe and awkward. Walking on level ground is easy because the knee is not bent much. But when the leg is flexed, as in walking downstairs, the patella slips out and a bad fall results. Carrying of weights is also often impossible. The reason of the sudden fall is not only that the knee is deprived of support, but as the patella slips the quadriceps extensor becomes a flexor.

Displacement inward is associated with severe genu varum.

Treatment consists of removal of the primary condition in genu valgum and varum. If the patella remains unstable then it can be braced up by taking a reef in the extensor tendon, or by separating the tubercle of the tibia with the ligament attached and fixing it farther inward, or lower down, as circumstances dictate. In less marked degrees of slipping, an apparatus with semilunar plates on either side of the patella often suffices to keep it in place, especially if the flexion at the joint is limited to 45° for a time.

In one case of persistent outward displacement of the patella the author grafted the sartorius into the upper and inner part of the bone with much success. No inconvenience took place and the leg was quite firm.

Elongation of the Ligamentum Patellæ and Slipping Patella

These matters have been discussed in the preceding article on displacement of the patella, and repetition is needless, for the conditions are so closely associated.

Enlargement of the Tubercle of the Tibia[1]

Synonym—Schlatter's Disease.

The tongue-shaped lower portion of the upper epiphysis of the tibia, frequently developed from a separate centre, becomes enlarged and painful, principally in young growing people much given to athletic exercises; occasionally from a blow upon it, or from the effects of indirect violence, met as a sudden strain coming upon the

[1] Cf. F. Osgood, *Boston Med. and Surg. Jour.*, Jan. 29, 1903; Alexis Thomson, *Edinburgh Med. Jour.*, March 1908; also R. C. Elmslie, "Enlargement of the Tubercle of the Tibia," *Brit. Jour. Children's Diseases*, Jan. 1911, p. 9.

partially extended knee. Very rarely the epiphysis is affected by rickets, tubercle, or syphilis.

It is usually seen in young people about the age of puberty, and, according to Bradford and Lovett,[1] more often in boys. Alexis Thomson thinks that "the affection . . . is predisposed to and is much more liable to occur in youths, in whom the tongue-like

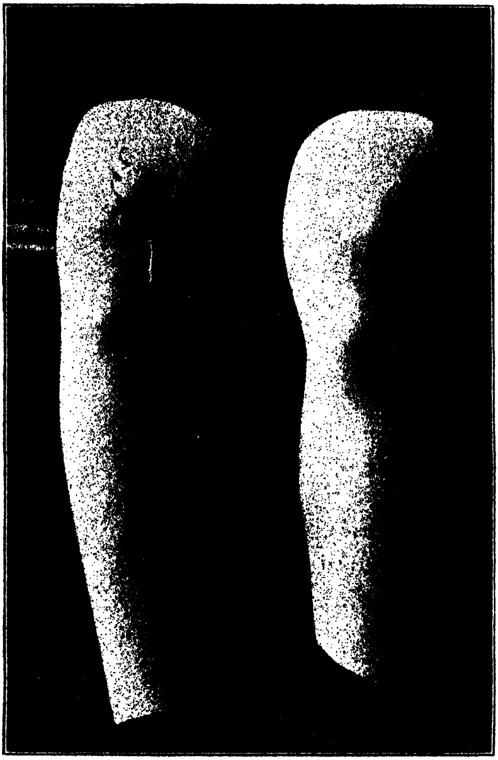


FIG. 238.—Anterior view of case of Schlatter's Disease (Bilateral), in a lad aged 14 years.

process of the tubercle has a separate centre of ossification." He adds that, "according to Dr. W. H. Barrett of Southport, the affection was formerly known as 'Rugby-knee'; that it was recognised as a bar to taking part in military drill because of the incapacity to kneel on the affected limb; and that the rounded projection of the upper end of the tibia, which characterises the affection, may persist throughout life."

[1] Bradford and Lovett, *Orth. Surg.* 3rd edition, p. 227.

In a case which recently came under the author's notice, the affection appeared spontaneously in the left knee of an enormously overgrown, weedy lad of twelve years. Enlargement of the tubercle and of the adjacent bone, with surface-heat, pain, and tenderness, were present. So long as the knee was held quiet in a splint he felt comfortable, but so soon as he began to use the part the

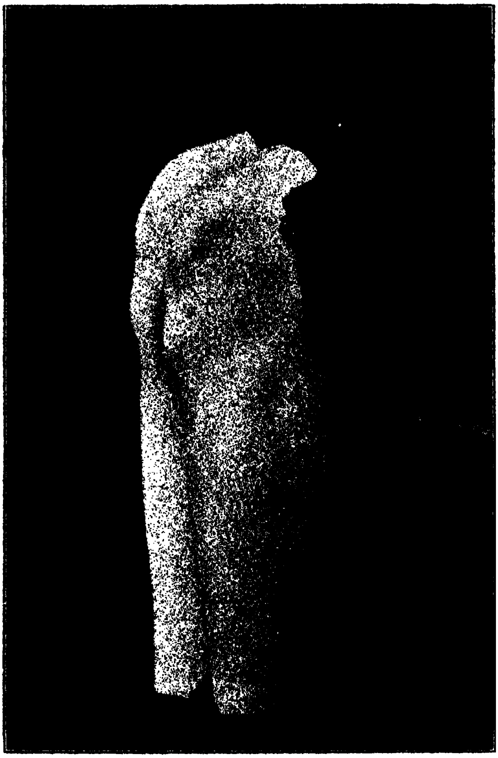
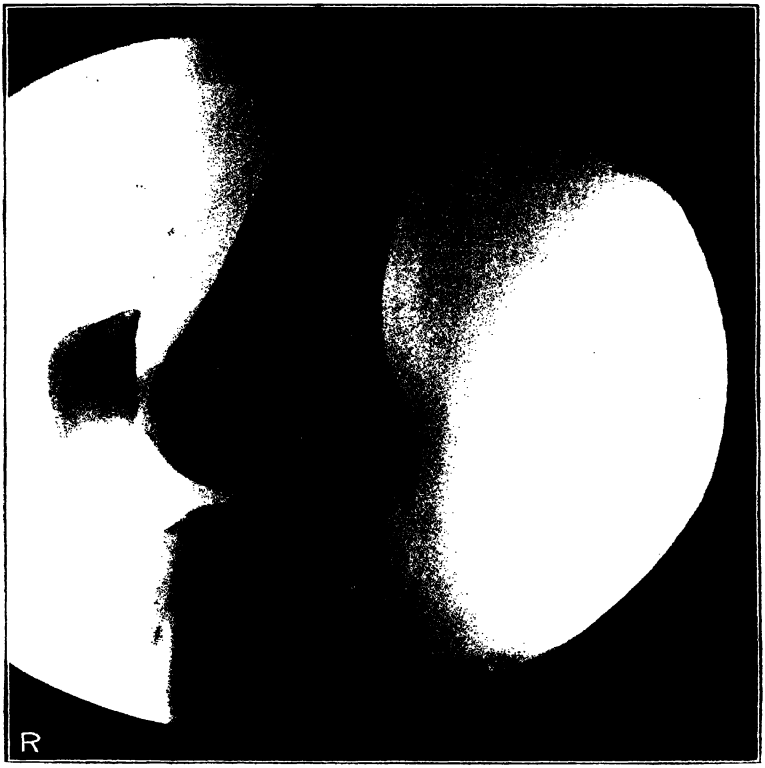


FIG. 239.—Lateral view of the knees in the preceding figure. Note the Prominences over the Tubercle of the Tibiae.

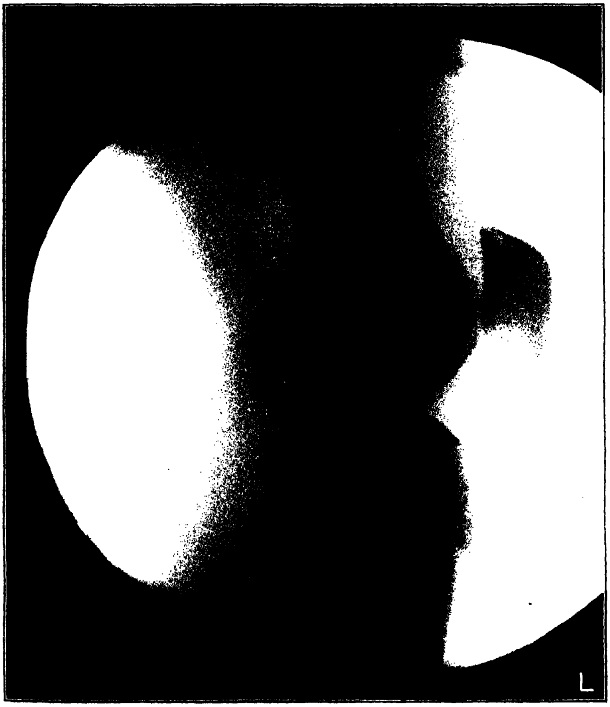
symptoms returned. An X-ray photograph showed no tuberculosis, merely an enlarged tongue-shaped process of bone, widely separated from the shaft of the tibia by a space which was irregular and fluffy in appearance (Plate XXI.). As palliative treatment had been tried for several months and failed, and as the boy's health was suffering from want of fresh air and exercise, I trephined the epiphysis in order to relieve the congestion, and he recovered. The X-rays of

PLATE XXI.



Radiograms, taken laterally, of the right and left Knees of a boy aged 14 Years.

PLATE XXI. (*Continued*).



ing from Schlatter's Disease. Note the Hypertrophy of the Tubercle of the Tibiae.

the case are figured here, and Alexis Thomson gives two figures in the *Edinburgh Medical Journal*, March 1908. It is generally believed that the majority of the cases are due to a local hyperæmia of the epiphysis.

Symptoms.—In the traumatic cases sudden pain and swelling and occasionally ecchymosis are present from the first. In other cases a gradual enlargement of the tubercle with pushing forward of the ligamentum patellæ at its lower part is seen, and the onset of pain is gradual and not sudden. Careful examination of the part and inquiry into the patient's history are necessary to decide the cause of the trouble. In most cases the affection disappears spontaneously.

Diagnosis.—The difficulty is to distinguish inflammation of the bursa[1] behind the ligamentum patellæ from enlargement of the tubercle. Moreover, it should be remembered that bursal inflammation is often secondary to bone lesions. Fluctuation is present when the bursa is distended with fluid, but X-ray examinations are not very helpful as the tubercle is often partially ossified. As Lovett points out, during normal ossification, at puberty, the tubercle appears to be loose from the tibia; and he adds that "only when there is a marked difference in the radiographs of the two knees, and the tibial tubercle is displaced upward, is one justified in diagnosing any displacement of it."

Treatment.—Having ascertained whether the cause is trauma, rickets, syphilis, or tubercle, we proceed to treat the affection by general means, and locally, in the cases of syphilis and tubercle, by applying Scott's ointment (Ung. hydrarg. co.) or Hydrargyri oleat., 10 per cent, and fixing the limb in extension until the irritation has subsided. If it is persistent, an incision is made and the tongue-shaped epiphysis is trephined or removed.

In traumatic cases the leg is held in extension on a splint for three weeks, and the irritation subsides.

Right-angled Contraction of the Tendo Achillis[2]

The condition to be described comes before us in different clinical guises, the apparent discrepancy being due to the degree of departure from the normal. We will briefly indicate some of the phases which are met with.

[1] Lovett, *Philad. Med. Jour.*, Jan. 6, 1900.

[2] A paper by the author in the *Reports of the Society for the Study of Disease in Children*, vol. vii. 1907, is reproduced here.

A child is brought for advice by his parents with a statement that he very soon becomes tired in walking, has pains in his calves and around the knees. He is not able to run well or swiftly, and shortly after starting he stumbles and falls; and the scars about the upper part of the tibiæ and over the patellæ testify to the truth of this statement.

A second type of case is seen by the surgeon, because the gait is shambling, and the child walks with short steps and the knees bent. He is found to be unable to make longer steps without bending the knees more. This child, too, is incapable of taking the same amount of walking and running exercise as his school-fellows.

A third variety is that in which a sprained ankle is constantly occurring.

A fourth class of case, and that most frequently met with, is the child who comes with so-called flat feet, these members being held in an everted position. Yet, it is noted that while there is undoubted eversion present, the arches have not fallen. The reverse is often the case, and the arch is exaggerated.

A fifth type is the child brought to see one in consultation, because he turns his toes in and walks on the outer side of the foot.

A sixth type is the female who has worn high heels for years. She usually complains of frequently sprained ankles or appears to have flat feet.

Now all these different clinical states are referable to one underlying cause. In the normally constructed individual, if the knee is fully extended, and the important point is in the word *fully*, the foot is capable of dorsiflexion, so as to make an angle of 72° with the leg, that is, 18° less than the right angle. This fact can be readily verified by measurement with a goniometer. In the act of walking, at one particular moment it is essential that this power of complete dorsiflexion of the foot be fully exercised. For example, when the step forward is being taken, presuming that the right leg is in advance, the left foot is at that moment firmly planted toe and heel on the ground, bearing largely the weight of the body. In order to give the impetus to the stride, and at the same time to maintain the weight of the body, the left knee is fully extended, and the foot is dorsiflexed at the ankle to the extent of 18° less than a right angle. If the angle of dorsiflexion is decreased the stride must be accordingly lessened, or the patient will be in uncertain equilibrium if he attempt to take a normal step. The explanation of all the clinical phases described above is found in varying degrees

of loss of the angle of dorsiflexion. Loss of dorsiflexion is due, in these cases, to some degree of contraction of the calf muscles and of

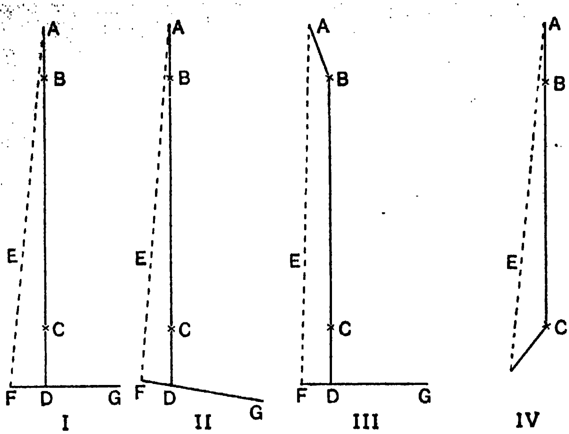


FIG. 240.—To show the effects of Right-Angled Contraction of the tendo Achillis upon the knee and the foot respectively. A, point of attachment of the gastrocnemius to the lower end of the femur. B, knee-joint. C, ankle-joint, and between B and C, bones of the legs. F, attachment of the tendo Achillis to the os calcis. F D G, general direction of foot. E, dotted line representing the calf muscles and tendo Achillis. In I. the structures are normal. In II. the calf muscles and tendo Achillis are shortened, and the patient cannot bring the heel F properly to the ground at the same time as the toes G. In III. the knee is bent, so as to lessen the distance A F, between the lower end of the femur and the tuberosity of the os calcis, but the ankle is neither inverted nor everted. In IV. the knee is held in extension, but the foot is deviated at the ankle C either into valgus or varus. I. II. III. are drawn in the antero-posterior plane, and IV. in the transverse plane.

the tendo Achillis. Clinically we find that the usual condition is that the foot, with the knee fully extended, cannot be dorsiflexed

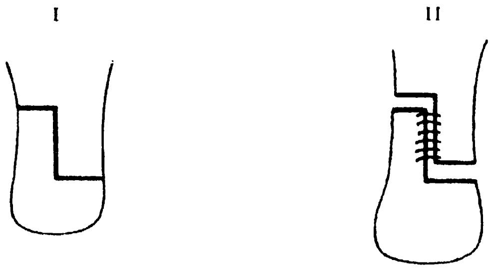


FIG. 241.—I. Tendo Achillis and Z-shaped section. II. The two portions of the tendo Achillis have been drawn on each other to the required length and are united by sutures.

beyond a right angle. Sometimes the condition is not so marked as this, there being 5° or even 10° of dorsiflexion; the fact remains,

however, that free movement at the ankle in the direction of flexion is limited, and it invariably produces unpleasant results.

Thus in the first type of case the patient becomes tired because his stride is habitually shortened, and the strain upon the calf muscles and tendo Achillis accounts for the pain and weariness in those parts.

In the second type of case, viz. the shambling gait, the explanation is quite obvious. If the calf muscles and tendo Achillis are too short, one of two things must result if rapid progression is desired. The patient must either walk partly on his toes, with the heels slightly off the ground; or bend the knees so as to relax the calf muscles and tendons, and thus obtain full dorsiflexion at the ankle.

In the cases with frequently sprained ankles the explanation is that the habit of bending the knees in walking has not been learned; and at the particular moment of striding forward, the foot in the rear is not planted firmly on the ground, but is in a condition of unstable equilibrium; so that if it rests on any inequality it is readily twisted inward or outward, and a sprain results.

In the fourth and fifth types, the flat-footed patient and one walking with inverted feet, the mechanics are equally simple. The distance between the lower end of the femur and the heel can be shortened to accommodate the contracted structures in one of two ways, by turning the foot either outward or inward at the ankle. In both cases, in place of two parallel lines, composed of the lower end of the femur, the tibia, the astragalus, and os calcis on the one hand, and the calf muscles and tendo Achillis on the other, lying in the same sagittal plane, a triangle is formed. The base of the triangle is the shortened muscles and tendon, the apex of the triangle is at the ankle. One side, made up of the bones above the ankle, is much longer than the other, composed of the bones below the ankle-joint.

This simple and seldom described condition of contraction may always be suspected if the heads of the metatarsal bones are found to be prominent in the soles of the feet, and is certainly present when a row of corns is formed over the projecting bones. In many cases, if allowed to proceed unchecked, the condition develops into ordinary talipes equinus, about which no doubt can exist. The object of these remarks is to insist upon the necessity of recognition and the importance of treating these slighter degrees of contraction.

A word at this point as to the method of examination. The patient should be seated, the knee fully extended, and the foot

brought into a straight line with the leg. The foot should then be slowly dorsiflexed, and the moment resistance is encountered or pain is elicited passive movement should be stopped and the angle taken by the goniometer.

Caution is necessary. No abrupt or rough movement must be used in ascertaining the angle of dorsiflexion, or spasm will be set up in the calf muscles, and the degree of contraction will appear larger than it is. The movement of dorsiflexion of the foot should be slow, gentle, and steady, and the attention distracted while it is being tested. The bones above and below the ankle must be held in one right line, and it often happens that one examination is not sufficient to determine the degree of the trouble or to decide what line of treatment should be adopted. If the sufferer is cold, frightened, or fatigued, the extent of loss of normal mevement is often exaggerated. It is advisable in many cases to see a child on a second occasion, when it has had a night's rest, and when the parts are warm. These conditions may make a difference of 5° to 10° in the estimation of the angle of dorsiflexion.

As to the cause of this right-angled contraction of the tendo Achillis, it is found, in children, to be in most cases due to infantile paralysis, the incidence of which has fallen mainly upon the anterior muscles of the leg, which have all but recovered; in fact, by the ordinary tests they appear to have entirely recovered, but it is evident that the recovery is not quite complete, for there is a slight loss of balance between the anterior and posterior muscles, as is shown by the dropping of the foot when it is lifted from the ground. If equilibrium be once disturbed the calf muscles gain a mechanical advantage and contracture follows. The difficulty of walking and the symptoms described to the surgeon frequently begin after an exanthem, such as whooping-cough or measles, which we venture to think are more often associated with neuritis of the external popliteal nerve than is suspected.

Another set of causes is associated with throat lesions, such as tonsillitis of a doubtful nature and diphtheria. And in Anglo-Indian children we are frequently told that the child has suffered from one or two attacks of "fever," whatever that may mean. With fashionable women high-heeled boots are undoubtedly directly causative.

The question of *treatment* is sometimes a difficult one. If the foot of the fully extended limb be incapable of dorsiflexion beyond a right angle, the proper thing to do is to lengthen the tendo

Achillis. This should not be done by simple section, as it is not easy to regulate the exact length of the band of new tissue between the severed ends of the tendon. It is difficult to prevent the parts healing with too long a union, so that talipes calcaneus results. Therefore an open operation, in which the tendo Achillis is lengthened to the requisite amount by the Z-shaped method, is done. A transverse incision is first made half-way through the tendon, and then the knife is carried vertically downwards for a distance of a half to one inch. It is then turned on the flat, and the remaining part of the tendon cut through transversely. The two portions are drawn upon one another until the requisite degree of lengthening, which can only be learned by experience, is obtained, and then they are stitched together (Fig. 241). In this way firm union is obtained, and all risk of undue lengthening avoided. In those cases where there is a diminution of only 5° or so of the angle of dorsiflexion, an immediate operation is not to be advocated, but passive and active movements, designed to stretch the contracted structures, should be sedulously practised; and much assistance is afforded by prescribing a surgical boot, with an outside steel to the calf and a toe-uplifting spring, the constant action of which stretches the shortened soft tissues. If this manœuvre fails, we can always resort to the simple operation previously mentioned.

In hill-climbing, it is often a matter of surprise that guides can stand on slopes where the amateur cannot, and that after making every allowance for their training. Dr. Wherry, of Cambridge, has written an interesting book on *The Climbing Foot*, showing that the normal range of movement at the ankle of mountain-climbers is 10° to 15° greater than that of town dwellers.

I have verified his observations by measuring the range of movement of the foot at the ankle in guides. It stands to reason that with 10° to 15° additional movement at the ankles, guides can stand securely on slopes 10° to 15° steeper than amateurs can. These observations explain how some rowing men are able to make full use of a sliding seat without fatigue, and others whose tendo Achillis are contracted become tired very soon. In the case of the latter, an alteration in the angle of the "stretcher" will render the fatigue less.

Talipes Arcuatus and Plantaris or Pes Cavus

Synonyms—English, *Hollow-foot*; French, *Pied Creux*; German, *Hohlfuss*.

In these deformities there is increased concavity of the arch with corresponding dorsal convexity. According to Mr. F. R. Fisher

Fig. 242.—Talipes Arcuatus in a boy aged 5½ years.

the term talipes arcuatus is applicable to the raising of the arch of the foot when the heel and the balls of the toes are in one horizontal

Fig. 243.—The same Foot as in Fig. 242 restored.

plane. If the balls of the toes fall below the level of the heel, and the arch is at the same time increased, then the condition known as talipes plantaris is present. Pes cavus is applied to any state of the foot in which the arch is increased.

Frequency.—Of 5079 cases of deformity in the author's hospital practice, 903 were talipedic, and 97 were examples of arcuatus and plantaris.

Authors divide pes cavus into two kinds, congenital and acquired. I have not met with any marked case of the congenital variety, although, according to Duchenne, some instances of pes cavus, due to paralysis of the interossei and lumbricales, are occasionally congenital, but more often acquired. Any patient born with a very high arch may be looked upon as a subject of pes cavus. In such instances it is stated by Reeves that the inner division of the plantar fascia is contracted.

FIG. 244.—Contracted Foot.

Talipes arcuatus and plantaris (pes cavus) of the acquired variety are due to the following *causes*:—

1. *Slight* paralysis of the anterior muscles of the legs, from multiple neuritis during dentition, after measles, scarlet fever, chorea.[1]

2. In combination with talipes calcaneus, *vide* p. 339. The condition of the distorted feet of Chinese ladies is said by Adams to be similar to that of calcaneus; but the appearance of such feet in the Hunterian Museum is rather that of talipes plantaris than calcaneus.

3. Co-existing with paralytic talipes equinus due to anterior poliomyelitis, and found also in Friedreich's disease.

[1] Very often this condition of pes cavus is associated with right-angled contraction of the tendo Achillis.

4. A distinct variety is said to be due to the exaggerated action of the peroneus longus, with increase of the convexity of the arch in the transverse section of the foot (*pied creux valgus*).

5. A high arch with contraction of the plantar fascia is found in children and adults, the subjects of rheumatism, or in those whose parents have suffered from that affection.

6. In children or young adults who have worn boots too short, the toes and heels become approximated, and contraction of the structures in the sole of the foot takes place.

7. In women who have worn boots too small and with high heels.

8. According to Duchenne, the *griffe pied creux*, or clawed foot, follows paralysis of the interossei and lumbricales, the adductor pollicis, and flexor brevis pollicis. In this form the arch is much increased, the heads of the metatarsal bones are depressed, the first phalanges are hyper-extended, while the second and third are flexed (cf. the position of the fingers in ulnar paralysis).

The point advanced in support of the statement as to the paralysis of the interossei and other muscles being the cause of the plantaris is the loss of irritability of these muscles to galvanism, but pathological proof is lacking.

To revert to talipes arcuatus (see Fig. 242) and plantaris due to slight paralysis of the anterior muscles of the legs following acute illness, I cannot do better than quote in a somewhat abbreviated manner the very able description of these affections given by my colleague, Mr. F. R. Fisher.[1] Regarding the subject of paralytic deformity of the foot in a new light, he has shown that talipes arcuatus, plantaris, and equinus are but degrees of deformity dependent on the same existing cause, viz. less or greater paralysis of the anterior muscles of the foot and leg.

"Talipes arcuatus is characterised, as the name implies, by increase in the height of the arch of the foot; the condition presents no very visible indication of structural defect, but if an impression be taken of the sole the existence of abnormality will be at once detected. The extent of the treading surface is considerably less. Arcuatus results from slight paralysis of the muscles of the leg, which is usually the sequel of scarlet fever, diphtheria, or other exhausting illness. Upon recovery from such an attack, some little awkwardness of gait may have been observed, or it may have been noticed that the shoe was worn away more quickly at the front part

[1] "On Paralytic Deformity of the Foot," *Lancet*, 1889, vol. i. pp. 142, 214.

of the sole than elsewhere. These slight symptoms exist perhaps for a few months; they pass off, the child 'grows out of' his bad habits of gait, and there is apparently an end of the matter. The transitory lameness is due to the anterior muscles of the leg being chiefly affected with loss of contractile power. During this period of existing weakness of the flexors the front of the foot becomes slightly depressed at the transverse tarsal joint. . . . When the paralysis passes off, the front of the foot is again brought to its proper position, but as growth proceeds there is a want of accommodation of the contracted tissues (in the sole)[1] to the increase in length of the other parts, and thus an abnormal degree of arching is gradually established. The condition of arcuatus develops so slowly that it seldom causes inconvenience until the age of adolescence is reached; relief is then sought from pain in the sole of the foot and from reflex muscular spasm extending up the front of the leg, both of which symptoms are chiefly due to the formation of corns beneath the heads of the metatarsal bones. . . . The pain caused by arcuatus is not infrequently ascribed to rheumatism; but the corns on the front part of the foot, the string-like bands of fascia, and the loss of treading surface, ought to indicate the real source of the trouble.

"Talipes plantaris is an aggravated condition of arcuatus, and forms a connecting link between the latter and talipes equinus. In this more severe state of distortion the sole is contracted and the arch deepened, as in the case of arcuatus, but the front of the foot is also depressed below the level of the heel. The early condition described as present in the slighter deformity has here become permanently established. The muscles of the leg and foot are all implicated, but the extensors of the toes and tibialis anticus are especially affected. . . . Lameness continues for a somewhat lengthened period, and the anterior muscles never recover sufficient strength to raise the depressed portion of the foot to its normal position. . . . It should be added that the toes are

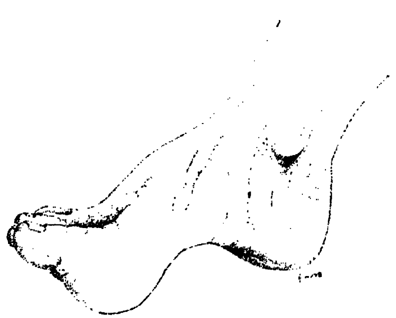


FIG. 245.—Talipes Plantaris.

[1] The words in the brackets are the author's.

frequently hyper-extended." In illustration, we quote the following case:—

CASE 5. *Paralytic Talipes Arcuatus and Plantaris.*—Thomas G——, aged nine years, was brought to us for pain in the feet and difficulty in walking. The family history is that the maternal grandfather suffered from rheumatism; and the mother has rheumatic pains in the legs. When two years of age, the child suffered from whooping-cough, and when six, from measles. He now complains of pains in the feet and leg.

On examination of the feet, the right presents the appearance described above. This foot is a good example of talipes plantaris and the left foot of talipes arcuatus, *i.e.* the earlier condition of plantaris (Fig. 242). In neither foot is the tendo Achillis shortened. The deformity was remedied by section of the plantar fascia and the use of a rectangular tin-shoe.

FIG. 246.—Tracings of Soles of Feet in case 5 when standing. The right foot was in the condition of Plantaris, and the left of Arcuatus.

The *treatment* consists of division of the plantar fascia; after which extension should not be made for fourteen days. Then the best apparatus is a Scarpa's shoe, with a single uplifting movement in the sole and slots with webbing for the toes. The raising of the front part of the foot should be done gradually, as some pain incidental to the rapid method is thereby avoided. A walking apparatus with a toe-uplifting spring is also necessary afterwards. After section of the plantar fascia, a troublesome, painful, thickened scar sometimes forms at the site of section. This is due either to premature stretching of the sole, or to allowing blood to accumulate beneath the skin at the site of operation, or a hæmatoma sometimes arises suddenly when weight is borne on the foot. In all cases gentle massage and painting with lin. iodi. will remove the pain, promote the absorption of the scar tissue, and the patient should not use the foot until the thickening has disappeared. Injection of fibrolysin into the sole of the foot is very useful if the thickening is persistent.

In severe and relapsing cases of talipes plantaris, where the ball of the great toe forms an unsightly and painful prominence, and the

cavity of the arch cannot be reduced by fasciotomy and wrenching, I advocate one of the following procedures:—If the patient is under eighteen years of age, excision of half an inch of the shaft of first metatarsal bone. If the patient is over that age, excision of half an inch of the base of the first metatarsal bone, the epiphysis having joined at that age. If the ball of the great toe is very prominent and painful, excision of the head of the first metatarsal bone is useful. In those instances, where all the metatarsal bones are very obliquely placed, and cannot be replaced, a method of operation communicated to me by Mr. Robert Jones is invaluable. It consists of removing through separate incisions on the dorsum of the foot, a half to one inch from the shafts of the first to the fourth metatarsal bones, toward the bases, avoiding the epiphysial line of the first metatarsal and not opening the joints. The fifth metatarsal bone is not touched, as it is very seldom obliquely placed, and, further, serves as a splint to the other bones.

CHAPTER III

THE VARIOUS FORMS OF ACQUIRED CLUB-FOOT

Talipes Equinus

Synonyms—French, *Pied bot équin*; German, *Pferdefuss, Spitzfuss.*

The essential feature of this variety of deformity is an inability to place both the toes and heels on the ground at the same time, and the patient walks on the heads of the metatarsal bones. Subsequently contraction of the soft parts in the sole of the foot ensues, and necessitates division of the plantar fascia, and it may be of the deeper structures.

Degrees of Talipes Equinus.—The foot should normally be capable of dorsiflexion on the leg to the extent of 18° beyond the right angle. Any condition in which this angle is diminished at the ankle-joint without inversion or eversion is rightly called talipes equinus. A few degrees of diminution are not of import, but if the foot cannot be flexed beyond the right angle, then there exists—

The First Degree, or Right-angled Contraction of the Tendo Achillis, which is already described.

The Second Degree.—The heel is raised well off the ground, and a transverse crease is seen above it. Progression takes place on the heads of the metatarsal bones, and decided lameness is present, due partly to the extended foot and partly to large and inflamed corns. In congenital and spastic cases, a broadening of the front part of the foot, owing to the "spreading" of the heads of the metatarsal bones and separation of the toes, is seen. This appearance is all the more striking from the ill-developed state of the heel. Here the skin is thin and shows no signs of pressure; the tuberosities of the os calcis are absent, so too is the natural pad of fat. The great toe is drawn towards the middle line of the body, and the inner border of the foot is concave. This appearance simulates that of slight

varus, but in the latter case the site of deformity is at the medio-tarsal, and not at the metatarso-phalangeal joint, as in the former. The limping gait in paralytic cases and the jerky step in spastic are characteristic. The plantar fascia is frequently contracted in this stage. Noticeably in paralytic cases, and to a less degree in spastic, the head of the astragalus forms a distinct prominence on the dorsum of the foot.

The Third Degree is an exaggerated condition of the second. So much extension is present that locomotion may take place on the

FIG. 247.—Paralytic Talipes Equinus before Treatment.

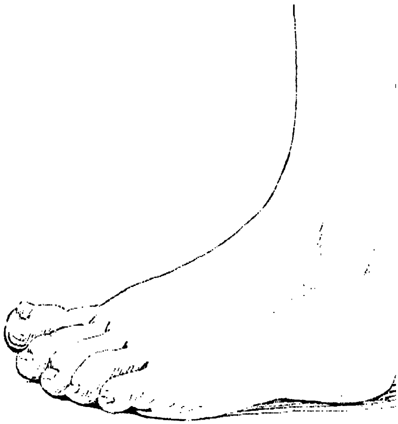


FIG. 248.—Paralytic Equinus after Treatment.

dorsum of the foot. It is bent completely backwards, and the toes are, as it were, "tucked underneath." If one foot alone is affected in the second or third degree, the patient is often able to hobble about fairly well. But when both feet are deformed, walking may be impossible.

Occurrence and Causation.—Whilst talipes equinus is the rarest of congenital, yet as an acquired deformity of the foot it is one of the most frequent. The causes of it are:—

(*a*) Spastic, viz. from infantile hemiplegia—spastic paralysis.

(*b*) Paralytic, from infantile paralysis and multiple neuritis.

(*c*) Traumatic, from injuries to the ankle-joint and anterior tibial nerve.

(*d*) Cicatricial, from burns on the back of the leg, or laceration of the calf-muscles.

(*e*) Retention of the foot in a vicious position, *e.g.* the pointed feet of bedridden patients—talipes decubitus.

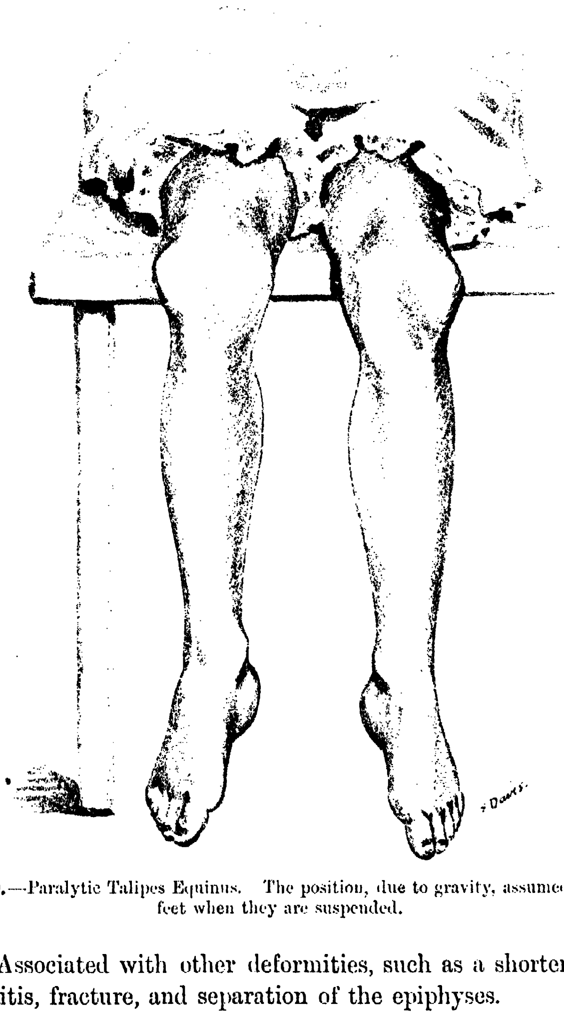


FIG. 249.—Paralytic Talipes Equinus. The position, due to gravity, assumed by the feet when they are suspended.

(*f*) Associated with other deformities, such as a shortened limb from coxitis, fracture, and separation of the epiphyses.

(*g*) Inflammation, rheumatic or tuberculous, of the ankle.

Practically we have to consider two classes, the spastic and paralytic.

There are essential *differences* in the feet according as *spasm* or *paralysis* is present, viz.:—

In spastic cases the heel is much raised, the arch somewhat deepened, but the foot is in a direct line with the leg, and there is no sharp curve at the medio-tarsal joint. Whereas in paralytic cases, it is not so much that the heel and posterior part of the

FIG. 250.—The same patient as in Fig. 249, showing the position assumed by the feet when the patient is lying down.

foot are raised, as that the front part of the foot is dropped. In this event the head of the astragalus and dorsal surface of the scaphoid are very prominent (*vide* Fig. 251). The toes in a spastic case are hyper-extended at the metatarso-phalangeal, and flexed at the first inter-phalangeal joint, and so present a claw-like appearance. In paralytic cases of the first degree they are extended fully on themselves, and in the second degree they are

hyper-extended at the metatarso-phalangeal joint, whilst in the third they are entirely flexed into the sole.

In all forms of club-foot the following points hold good in the diagnosis of congenital, spastic, and paralytic talipes.

In the *congenital* cases the deformity is present from birth, and is frequently bilateral. In the majority of cases it is either equino-varus or varus. Much resistance is offered to any attempt to straighten the foot; there is little or no interference with the nutrition of the foot in early cases. In the *spastic* variety one or both feet are affected. Equinus is a common deformity; the affected muscles are tense, rigid, and resistant; the nutrition of the limb becomes affected ultimately, and the contracted muscles atrophy; the reflexes are increased. In the *paralytic* cases very often one foot only is involved; the affected muscles are lax and flabby, and give the reaction of degeneration; the reflexes are diminished or lost; the limb is wasted, and shorter than its fellow; its temperature is diminished, and it is cold and blue, and trophic lesions of the skin may be present.

The Morbid Anatomy of Talipes Equinus.—Inasmuch as the foot is not deflected laterally, the alterations in the bones and soft parts are not marked, nor are they sufficient to prevent the foot from being restored to complete usefulness.

The Bones.—A case is recorded by Adams[1] of a man, aged 25 years, whose foot showed no "material change" in the form of the bones. Usually these are altered in position and direction, but not in outline. The os calcis is either slightly elevated or remains horizontal. In congenital forms elevation of this bone is present, in paralytic cases it is absent. Rarely it may happen that the upper surface of the os calcis comes in contact with the posterior part of the articular surfaces of the tibia and fibula; such an occurrence, however, has been described. The head of the astragalus is directed downward and forward, and often stands out prominently on the dorsum of the foot; subluxation occurs at the astragalo-scaphoid joint. In severe instances the scaphoid and os calcis articulate.

In paralytic cases the equinus is seen to depend chiefly upon a dropping of the foot at the medio-tarsal joint, so that the cuboid and scaphoid are lowered in position, and displaced from the os calcis and astragalus. The metatarsal bones assume a vertical position, or are directed backwards, and are spread out

[1] *Path. Soc. Trans.* vol. iii. p. 468.

at their distal extremities. The compact bone-tissue is thinner and lighter than normal, and the cancellous and medullary cavities are filled with fat. Loss of cartilage occurs in those articulations which are the site of partial subluxation, *e.g.* from the head, superior and lateral articular facets of the astragalus, and the heads of the metatarsal bones.

Ligaments.—The dorsal ligaments are stretched, especially the superior calcaneo-cuboid and calcaneo-scaphoid, and the anterior part of the lateral ligaments of the ankle. The plantar structures are much contracted. The fascia is first affected, and then the inferior calcaneo-scaphoid and the calcaneo-cuboid ligaments are shortened. So too are the posterior parts of the lateral ligaments and the posterior ligament of the ankle. It is necessary to recognise the existence of shortening of the last-named ligament. In severe cases of long standing, section of the tendo Achillis is not sufficient to reduce the deformity, and the posterior ligament should be divided as well.

Muscles.—In paralytic feet, the extensors undergo fatty and fibrous degeneration whilst their opponents are shortened from want of opposition. In spastic cases, Guérin says that fibrous degeneration is present.

Tendons.—In addition to the tendo Achillis, the plantar fascia and the long flexors and the peroneus longus are shortened and tense. Later, the short plantar muscles retract.

Skin.—Corns and adventitious bursæ are present. In severe cases the former suppurate, and leave perforating ulcers. The skin of the sole is shortened, but after division of the deeper structures it will stretch.

Prognosis.—In congenital and spastic cases, so far as the deformity is concerned, the outlook is good; and the ultimate value of the limb for locomotion in spastic cases depends upon the subsidence of the spasm.

In paralytic cases we have to consider the prognosis from two points of view: (*a*) the ultimate shape of the foot; (*b*) the acquisition of voluntary power in the affected limb. As to the first point, the removal of the deformity does not present any great difficulty. It may be said that a shapely foot can, as a rule, be obtained.

Age is not a bar to success. Instances are recorded of cure of the deformity at the ages of 54 and 60 years.

The second factor in prognosis, the acquisition of voluntary

power in the affected muscles, is a different question. In infantile paralysis we must be guided by the number of affected muscles, and the extent to which power is lost. And it should not be forgotten that the first step towards the recovery of partially paralysed, or apparently entirely paralysed, muscles is relief from constant stretching and tension. One of the most important causes is the pull of their opponents, and this pull is increased when the normal muscles undergo contraction. It is a cardinal principle in the treatment of paralysis that the weakened muscles must be relieved of all strain caused by their opponents.

When the deformity arises from causes such as prolonged decubitus, we may say briefly that it presents a favourable prognosis, since there is no degeneration of muscle and no ankylosis. In those cases due to multiple neuritis, especially the alcoholic form, and those due to inflammation of the ankle joint, generally of a tuberculous or rheumatic nature, the outlook is the reverse of favourable.

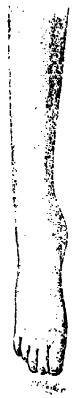


FIG. 251.—From a case of Infantile Paralysis. The dropping of the foot, owing to the paralysed condition of the anterior tibial muscles, is very apparent.

Diagnosis.—Pure talipes equinus presents in the second and third stages no difficulty in recognition. It is only in the first stage of right-angled contraction that it is likely to be overlooked. Under the title of "non-deforming club-foot," Shaffer[1] has described an affection in which the heel can be placed on the ground, but the anterior part of the foot cannot be raised. It appears to be a state of imperfect flexion at the ankle and medio-tarsal joints, and is very similar to, if not identical with, the condition described under right-angled contraction of the tendo Achillis.

It is often difficult to be sure of the cause of talipes equinus, but a careful inquiry into the history as to the mode of onset, the presence of tonic contractions elsewhere—especially of the adductors of the thighs—the absence, in spastic cases, of extreme muscular wasting, of coldness and the presence of excessive reflexes, will serve to distinguish them from paralytic cases. In the latter, if of moderate severity, before contraction of the sole has set in, it will be noted that, when the foot hangs, the dropping of the front

[1] Bradford and Lovett, *Orth. Surg.* 3rd ed. p. 576. Also Shaffer, *N.Y. Med. Rec.*, 23rd May 1885 and 5th March 1887.

part of the foot is very apparent (Fig. 251); but this sign in some cases entirely disappears when the foot is placed firmly on the ground.

The Treatment of Talipes Equinus.—The treatment of paralytic equinus is conducted on the following lines. In cases of the first degree, or right-angled contraction, manipulation and exercises may be employed. Walsham and Kent describe some exercises which they found "especially useful." "The patient stands with the soles flat on the ground, and then bending the knees and hips whilst holding the body erect, with the arms close to the side, endeavours to touch the ground with the finger-tips. This exercise should be performed, say, six times a day at regular intervals, and for five or ten minutes at a time. It may be varied by placing a wedge-shaped block of wood or other non-yielding material, 2½ to 3 inches high, beneath the fore part of the foot, and then in like manner, whilst bending the knees and hips and keeping the body erect, endeavouring to touch the ground with the tips of the fingers." A walking apparatus with toe-elevating spring and a "stop" at the ankle-joint to prevent undue plantar flexion, is necessary by way of after-treatment, and the application of a tin-shoe at night must be enforced. But time and trouble may be saved by lengthening the tendo Achillis. If there is contraction of the plantar fascia, it is divided before the tendo Achillis is lengthened.

In equinus of the second degree, division of the plantar fascia, followed by tenotomy of the tendo Achillis, is called for. It is advisable to make sure that the front part of the foot and the heel can be placed in an horizontal plane before the tendo Achillis is divided. The condition of the toes varies. Sometimes they are in a straight line with the metatarsal bones, at other times they are "clawed." If this condition of "clawing" [1] is present, the extensor tendons should be divided at the roots of the toes, and the con-

[1] The "claw-like" state of the toes is said to be due to paralysis of the interossei. This rests on the authority of Duchenne of Boulogne, who formulated the theory as the result of tests with the induced current. I am not aware that he verified it by actual dissection. In Walsham and Hughes' work the authors state that, in a specimen of equinus with clawed toes, the interossei were healthy. F. R. Fisher has clearly shown that the extent of paralysis is no measure of the degree of contraction which may ensue. In most of these cases of paresis or weakness of the anterior tibial muscles, clawed toes develop, and the cause of the clawing is simply the dropping of the front part of the foot with increase of the convexity of the instep and of the concavity of the arch. Therefore the origins and insertions of the long extensor muscles are brought nearer together than normal, and shortening takes place by adjustment. The explanation of the subsequent flexion of the toes at the interphalangeal joints is that the toes drop

tracted flexor tendons; also, if necessary, the lateral ligaments on the flexor surface of the toes are severed in the proximal interphalangeal crease, at the same time that the plantar fascia is cut.

The immediate after-treatment consists of the use of a metal shoe or plaster of Paris, according to the inclination of the surgeon. Great attention must be paid to active and passive exercises, to massage, and the use of the induced current. As soon as the union of the tendo Achillis is ensured, a walking instrument may be ordered. According to the degree of paralysis of the leg muscles, the walking apparatus should be single or double to the knee (Fig. 252), and a right-angled stop at the ankle is often advisable, especially if the union of the tendon is not very broad and strong. If there is laxity of the knee-joint ligaments, owing to paralysis of the extensors of the thigh, the instrument should be carried to the upper part of the thigh; or to the pelvis, if the affection is symmetrical. Double knee-caps and a ring-catch joint at the knee are helpful and convenient if the knee is very flail-like, and the shortening of the limb renders an additional thickness of sole necessary. One of the best means of restoring the muscles when the functions are in partial abeyance, is that of walking exercise, which can only be obtained after a division of all those structures which prevent the restitution of the foot to its normal position, and the application of a suitable instrument.

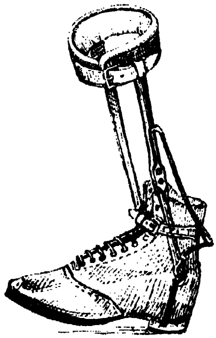


FIG. 252. Walking Apparatus, double to the Calf, for the Treatment of Paralytic Talipes Equinus.

In the third degree, time must be given for the inflammation of the skin around corns and false bursæ to subside, and then the foot is gradually unfolded, beginning with the front part, and finally letting down the heel by section of the tendo Achillis. After this there may remain considerable plantar flexion at the ankle, and the wrench may be called for. Should the use of this instrument not be sufficient, then astragalectomy is preferable to the other forms of tarsectomy.

first by gravity, and then adjustable shortening of the long flexors follows. So that the clawed toes are hyper-extended at the metatarso-phalangeal joints, and flexed at the first and second interphalangeal joints. Doubtless in cases of Friedreich's disease there is some loss of power in the interossei, and this may account for the clawed toes in this affection.

The after-treatment, both immediate and remote, is similar to that in the second degree. Congenital cases are treated on the same lines.

The Treatment of Spastic Cases.—In these cases the amount of comfort obtained by lengthening the tendo Achillis is considerable, and lasts for some years; and it is permanent if the spastic process has ceased. Tenotomy is also useful in cases of pseudo-hypertrophic paralysis. And in the pointed foot, the result of pro-

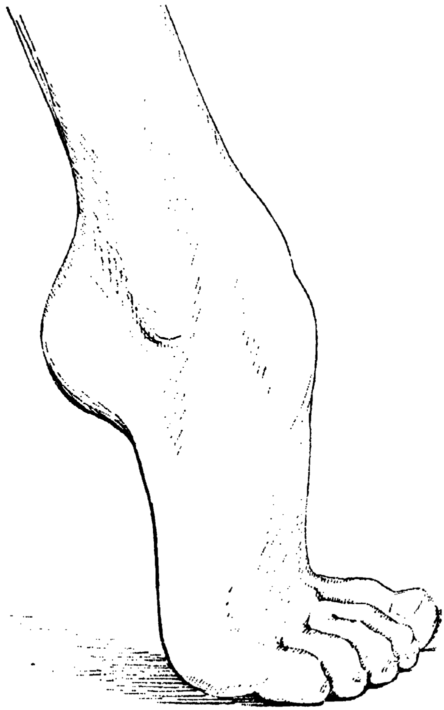


FIG. 253.—Paralytic Talipes Equinus, before Treatm.

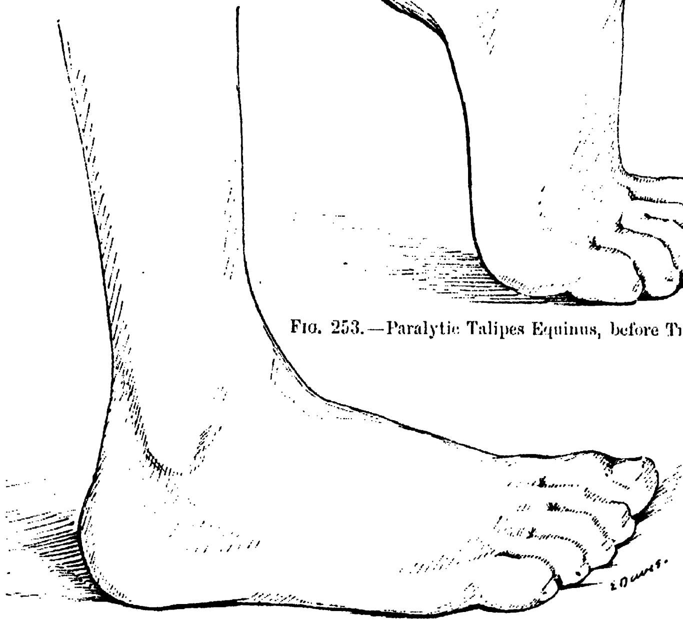


FIG. 254.—Paralytic Talipes Equinus, after Treatment.

longed decubitus, especially after peripheral neuritis, tenotomy of the tendo Achillis [1] may be called for.

[1] While there is no objection to placing the foot immediately at a right angle after section in paralytic and congenital cases, and putting the foot in plaster for the tendon

Talipes Calcaneus

Synonyms—French, *Pied bot talus*; German, *Hackenfuss.*

In talipes calcaneus the foot is held dorsally-flexed.

Causation.—This is an infrequent deformity. It is met with arising from congenital, paralytic, and other causes, such as want of proper supervision after section of the tendo Achillis, feeble union of the divided tendon, wound of the calf involving the tendon or posterior tibial nerve,[1] contraction of a scar from a burn on the anterior part of the foot, and in some cases of chronic disease of the ankle. The most usual cause is anterior poliomyelitis.

The feature of this distortion is the undue depression of the heel, with or without elevation of the toes. If the latter are elevated, the sole of the foot is not unduly concave. But when the anterior part of the foot and the toes are nearly, if not quite, on a level with the heel, then the concavity of the arch is greatly increased, and one form of pes cavus, or, as it is better named, talipes arcuatus, is present. Frequently, in long-standing cases, on the posterior aspect of the leg and just above the heel, a prominence is seen. It is formed by the lower ends of the tibia and fibula, which become conspicuous as the astragalus and foot are drawn forwards and downwards.

Acquired Calcaneus.—*Aspect of the Foot in Paralytic and other Forms of Acquired Talipes Calcaneus.*—The appearances presented

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to heal, yet in spastic cases more care must be exercised. If the foot is placed in plaster of Paris at once, the tendon is often found at the end of six weeks to have healed "too short," and the operation has to be done again. If the foot is placed in plaster of Paris at less than a right angle, then the bond of union is often stretched, and calcaneus develops. The best plan, we find, is to use a Scarpa's shoe for these cases, when the angle of the foot can be exactly adjusted from time to time, and the exact degree of lengthening obtained. It is curious to note that in spastic children, after section of the tendo Achillis, they develop a powerful reflex which causes them to dorsiflex fully the foot for a time after the section. Therefore, when the foot is not in a shoe or splint, the toes must be held down to prevent over-stretching of the bond of union in the Achillis.

[1] A most interesting case of calcaneus arising from this cause came under our care some years ago. A captain of Royal Engineers was going to his tent one night during the Tirah campaign, when a crawling Pathan slashed his left leg through a leather gaiter down to the bone, completely dividing all the structures. When we saw the patient, recovery of sensation in the posterior tibial nerve had commenced. It was necessary to divide the dorsiflexors, and restore the foot to the right-angled position, and retain it so. The case did perfectly well, and the patient resumed his military duties.

are totally different from those in the congenital form (*cf.* p. 292), and are essentially dependent, in the first place, upon dropping of the os calcis from lengthening of the tendo Achillis; and in the second place, upon contraction of the plantar fascia and deeper structures of the sole. The heel is abnormally lengthened and ball-like, and the tuberosities of the os calcis are prominent. This appearance is accentuated by the large pad of fat and thickened skin which forms over them, the result of undue pressure. The front part of the foot is raised, and cannot be brought to the ground at the same time as the heel. The foot may be more or less everted.

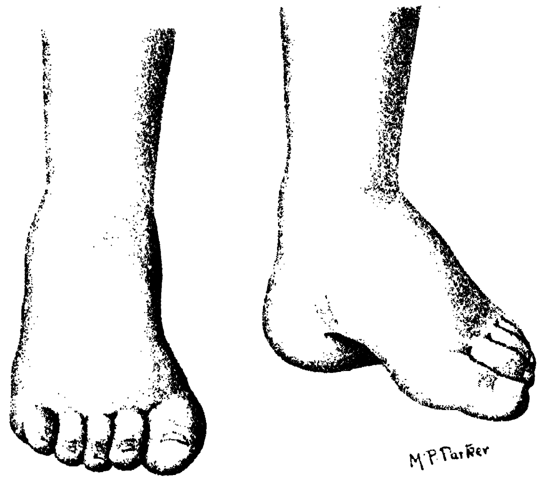

FIG. 255.—Talipes Calcaneus of the left foot from slight paralysis of the calf muscles.

At first the arch of the foot is not increased, but when the deformity is allowed to persist, the toes and heels are approximated, so that the arch is much deepened, and talipes arcuatus (pes cavus) follows. A deep transverse groove therefore forms in the sole of the foot. The legs, especially the calves, are very much wasted in paralytic cases, and the tendo Achillis is thin and membranous.

The different appearances in congenital and paralytic talipes calcaneus depend upon the following points:—In the congenital form the deformity is at the ankle-joint only; in the paralytic it is at both the ankle and medio-tarsal joints. In the congenital form the posterior tibial muscles are normal in strength and prevent the dropping of the os calcis. In the paralytic form these muscles,

being powerless, can neither prevent the heel dropping nor counter-balance, through the os calcis, the action of the long anterior muscles which are attached to the toes. The os calcis therefore drops, and is at the same time pushed out of its place by the extensors acting on the toes through the ankle and other joints. Partly by the pull of the extensors approximating the front and back of the foot, and partly owing to the effort made by the patient to bring the front of the foot to the ground, the deepening of the arch is progressive.

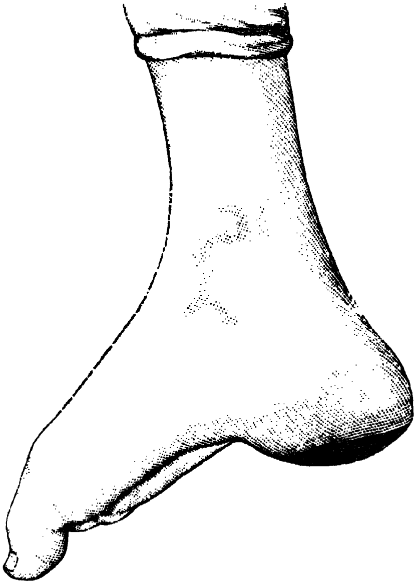

FIG. 256.—Talipes Calcaneus due to Paralysis of the Calf Muscles (Gastrocnemius and Soleus), illustrating the typical deformity of moderate degree (Whitman).

If the deformity is allowed to persist, the fasciæ and short muscles of the sole contract, and bring the heads of the metatarsal bones nearer the heel. Hence the arch is increased, and is possibly represented by a deep groove. (Cf. Figs. 256, 267.)

Symptoms.—In the congenital form the muscles are not wasted, nor is the leg cold, but the gait is awkward, slow, and ungainly; in the paralytic variety there is often lameness, and the heel strikes the ground first, whilst the fore part of the foot flops down. The foot can be much dorsiflexed, and the calf is wasted, with the tendo Achillis in a lax condition.

Morbid Anatomy.—Bones and Joints.—The long axis of the

os calcis is oblique and in extreme cases vertical, walking taking place on its posterior surface. The astragalus is displaced as a whole posteriorly, and there is great relaxation of the calcaneo-astragaloid ligaments.[1] At the medio-tarsal joint the scaphoid and cuboid have slipped downward and forward from the posterior portion of the tarsus; and in early stages there is undue movement at this joint. At the ankle-joint, plantar-flexion is scarcely possible, owing to the contraction of the anterior tibial muscles and

FIG. 257.—Paralytic Calcaneus, showing secondary changes in contour of Foot (Whitman).

shortening of the anterior ligaments. The posterior ligament is correspondingly lengthened.

Muscles and Fasciæ.—Much wasting and fatty degeneration of the calf muscles are seen in paralytic cases, while their opponents are shortened and tense. The short muscles and ligaments of the sole and the plantar fascia are retracted.

Skin.—Corns and adventitious bursæ form on the heel, while under the balls of the toes the skin does not show the natural

[1] This relaxation in paralytic cases is one of the reasons why shortening of the tendo Achillis and muscle-grafting have partially failed in the treatment of calcaneus.

thickness and hardness. In paralytic cases the integument is also cold, blue, and liable to chilblains.

Prognosis.—Since the appearance of the first edition of this work, where the outlook was described as bad, very great progress has been made in the treatment of paralytic calcaneus by muscle grafting combined with new methods of shortening the tendon, and by arthrodesis, so that the prognosis is now very hopeful.

Treatment.—That of the congenital form has already been alluded to on p. 293; but if the case is of a mild nature and refuses to yield to manipulation, the following tendons should be divided, viz. the extensor proprius pollicis, the extensor longus digitorum, with the peroneus tertius and the tibialis anticus. The foot is then retained in good position by some form of apparatus. Either the malleable iron splints, a metal shoe which can be plantar-flexed at the ankle, or plaster of Paris can be used. Passive and active movements so as to stretch the anterior muscles should be practised for a long time, and a boot (Fig. 258) with a toe-depressing spring worn.

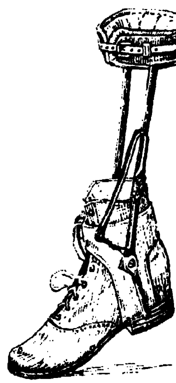

FIG. 258.—Walking apparatus for Talipes Calcaneus, with Toe-depressing Spring.

Acquired calcaneus, especially of the paralytic variety, is more difficult to treat on account of the alteration in the arch of the foot and the relaxation of the ligaments, particularly the calcaneo-astragaloid. The paralytic form may arise in two ways, either as a direct result of infantile paralysis or from excessive lengthening of the tendo Achillis after section for paralytic equinus.

The measures at our command for treatment are physiological, mechanical, and operative. The calf muscles must be assiduously massaged, and the constant current applied daily until they regain as far as possible their tone. In all cases, the tension on the calf muscles should be relaxed by lengthening the tendons on the anterior aspect of the leg.

Mechanical Treatment.—The objects are to raise the heel so as to bring the toes in contact with the ground a little before the heel, and to keep the arch of the foot as flat as possible. These results are effected by a walking instrument (Fig. 258), which may be single or double to the calf in severe cases, having a toe-depressing spring with a three-quarter stop at the ankle-joint, *i.e.* the joint

stopped a little over the right angle to prevent the heel dropping. In most cases a rubber-band or accumulator should be attached from the garter-piece to the heel of the boot, and a steel support placed on both the inside and the outside of the leg. For night-wear a tin-shoe with a quadrant is necessary; the quadrant being so adjusted that the sole-piece is at an angle of 110° with the calf-piece, and some extension is thus obtained. One point in fixing this shoe deserves attention. The heel is first fixed firmly in its place, and then, with the left hand drawing the heads of the metatarsal bones forward and slightly upward, the surgeon straightens out as much as possible the structures in the concavity of the plantar arch, and finally fixes the front part of the foot in position by a bandage. The use of walking apparatus is advisable in these cases for some years. Mechanical treatment is only of service in slight cases, or when the patient refuses operation for the more severe degrees.

Operative Measure for Acquired Calcaneus.—In nearly every case the plantar fascia requires section as a preliminary. We then have to choose between one of the following; and in doing so we should recognise that acquired talipes calcaneus is not merely a lengthening of the tendo Achillis. It is a relaxation and lengthening of the posterior ligament and posterior parts of the lateral ligaments of the ankle, of the interosseous, and of the calcaneo-astragaloid ligaments, and comprises changes in the position of the os calcis and astragalus.

Operative measures are—

1. Section of plantar fascia, and wrenching the foot into position. In mild cases this answers fairly well, provided that the foot is retained for some weeks in plaster of Paris in a plantar-flexed position so as to permit shortening of the stretched ligaments.

2. Shortening of the tendo Achillis either by (*a*) the method of Willett or Gibney, or, better still, by (*b*) the Z-method, or by (*c*) transplantation of the tubercle of the os calcis.

(*a*) *Willett's Method.*[1]—"A Y-shaped incision some 2 inches in length is made over the lower end of the tendo Achillis down to the tendon. At the lower or vertical portion of the incision, the dissection is continued until the tendon is fully exposed over its superficial and lateral surfaces for the space of 1 inch in length, its deep connections being left undisturbed. The tendon is now cut across at the point of junction of the oblique portions of the

[1] *St. Bartholomew's Hosp. Rep.* vol. xvi. 1880, p. 309.

wound with the vertical. Next, the proximal portion of the tendon is raised, with its superficial connections to the integuments intact, to the extent of fully $\frac{3}{4}$ of an inch by dissecting along its deeper surface, *i.e.* by reversing the dissection made upon the distal segment. A wedge-shaped slice of the tendon is now cut off from both segments, that from the proximal being removed from the deep surface, whilst from the distal it is taken from its superficial; in both instances the faces of the wedge-shaped portions removed being at the point where the tendon has been divided. The heel being now pressed upwards, the proximal portion, including both skin and tendon, is drawn down and placed over the distal, thus bringing the prepared cut surfaces of the tendon into apposition. In this position they are held by an assistant, whilst four sutures, two on either side, are passed deeply through the integument, then through both portions of the tendon, and again out through the integument and fastened. When the operation is completed the united edges of the wound assume a V-shaped appearance, owing to the angle of the proximal portion being now attached to the terminal point of the distal portion of the original incision."

As Walsham pointed out, and it is in accordance with the experience of others as well as myself, plastic operations on the tendons of muscles, which are affected with infantile paralysis, are successful only when some healthy fibres are present in the muscles. It is useless to perform this or the other forms of tenectomy if the calf muscles give no reaction to electric stimulation. Elongation of the degenerated muscle-fibres will follow some months after the operation.

(*b*) *Gibney's Method.*[1]—A Y-shaped incision is made. The tendon is divided by a very oblique incision passing from below upwards and from behind forwards. The upper portion is then sutured as low down as possible on the lower, and the foot is placed well in plantar flexion.

(*c*) *The Z-Method.*—The tendon is exposed by a vertical incision over it. If necessary, the skin may be divided horizontally at the upper and lower ends of the vertical incision. The tendon, for example the right one, is severed thus. The knife is passed horizontally into it at its left edge, and half-way through it. The edge of the knife is then turned downwards, and the tendon split

[1] *Vide* the paper by V. P. Gibney in *Ann. Surg.* vol. xi. p. 241. Cf. twenty-eight cases treated by his method; seventeen gave a good result, eight a fair result, and three a poor result.

vertically for a variable distance according to the extent of shortening required. At the lower end of the vertical incision of the tendon the edge of the knife is turned to the right, and cuts horizontally through the remaining portion of the tendon, thus—

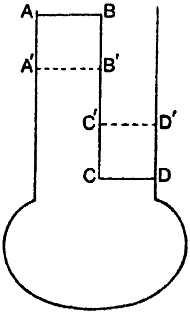

FIG. 259.—To illustrate the Z-Method of Shortening the Tendo Achillis.

From the rectangular part ABC a portion marked out by AB A′B′ is removed, and from the second rectangular part BCD a portion C′D′ CD is removed. Each part cut out is equal in length to the amount of shortening required. The part at A′B′ is united to AB and C′D′ to CD, and the sides of the vertical incision BC are sutured. By this operation the tendon is satisfactorily shortened, and there is not the same probability of stretching of the band of union as in some of the other operations.[1]

Transplantation of the Tubercle of the Os Calcis is rarely practised. The operation fails because the degenerated calf muscles stretch subsequently.

3. *Muscle-Transference.*—Nicoladeni's pioneer operation of transferring the tendons of the peronei into the tendo Achillis was done for paralytic talipes calcaneus. But it proved disappointing. We now see that to expect the comparatively weak peronei to do the work of the calf muscles, at least fourteen times as powerful, was very unreasonable. Only when the calf muscles are partially

[1] Phocas, *Revue d'orthopédie*, 1894, No. 5, p. 355, suggests this modification: "A median incision 5 or 6 centimetres long is made over the tendon, the sheath opened, and the tendon carefully denuded. It is then transfixed laterally at the upper end of the wound by a bistoury, which is carried down the middle of the tendon by a sawing motion. The posterior flap is cut away above and below, leaving the anterior part of the tendon thin enough to be folded on itself; and this is now done, thus shortening it one-half the length of the incision, and the fold is then stitched together with catgut. The sheath is closed, and the skin separated. The foot is then put up in equinus in a fixed dressing."

paralysed, and yet show no progressive recovery under treatment, is it advisable to employ this method alone.

4. *Operations on the Bones.*—(*A*) Whitman's; (*B*) Robert Jones'.

(*A*) Whitman's operation of astragalectomy, tendon transplantation, and backward displacement of the foot,[1] is particularly indicated in severe calcaneus, especially if combined with lateral deformity.

"A long curved external incision is made, passing from a point behind and above the external malleolus below its extremity and

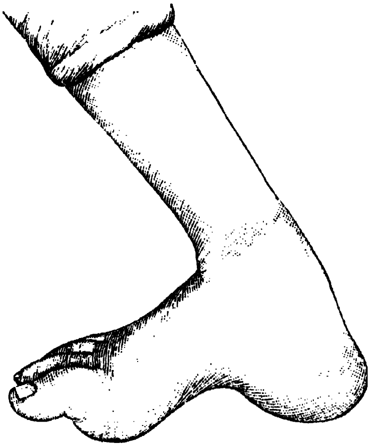

FIG. 260.—Talipes Calcaneo-Valgus. In this form the Adductors of the Foot (Tibialis Anticus and Posticus) as well as the Calf Muscle are paralysed (Whitman).

terminating at the outer aspect of the head of the astragalus. The peronei tendons are divided as far forward as possible, and they are then completely separated from their sheaths and drawn to one side. The joint is then opened, and the foot is displaced inward. This forces the astragalus out from between the malleoli, and it is easily enucleated when its attachments to the neighbouring bones have been divided. A thin section of bone is then cut off from the outer surface of the os calcis and cuboid bones. On the inner side the sustentaculum tali is cut away, and the calcaneo-navicular ligament is partially separated from its attachments. The cartilage is then removed from the two malleoli, and they are re-shaped to permit accurate adjustment. The foot is then displaced backward

[1] *Amer. Jour. Med. Sci.*, November 1901.

as far as possible, so that the external malleolus may cover the calcaneo-cuboid junction, while the inner is forced into the

FIG. 261.

FIG. 262.

Illustrating the effect of the Operation in restoring Symmetry (Whitman).

depression behind the navicular. Finally, the peronei tendons, if

FIG. 263.

FIGS. 261, 262, and 263 illustrate the effect of treatment by Removal of the Astragalus and Backward Displacement of the foot in cases of Paralytic Talipes Calcaneo-Valgus. In the later operations the backward displacement of the foot has been increased (Whitman).

the muscles are active, are attached to the insertion of the tendo Achillis and to the os calcis by strong silk sutures. The wound is

FIG. 1.

To illustrate Robert Jones' Operation for Paralytic Talipes Calcaneo-Cavus. Skiagram of the foot before operation (Robert Jones).

FIG. 2.

The same after the first operation (Robert Jones).

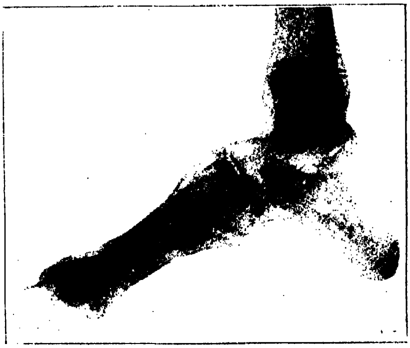

FIG. 3.

The same after the second operation, at the ankle (Robert Jones).

To face p. 98

closed without drainage, and the foot is then fixed by a plaster bandage in a position of equinus.

"The object of removal of the astragalus is to assure stability and to prevent lateral deformity by placing the leg bones directly upon the foot. The object of the backward displacement of the foot is to direct the weight upon its centre, and thus to remove the adverse leverage that induces dorsal flexion. The tendon-transference is an additional safeguard against deformity, and of some service in restoring function.

"As soon as possible the patient uses the foot in standing and walking. Ultimately apparatus may be dispensed with, but a brace

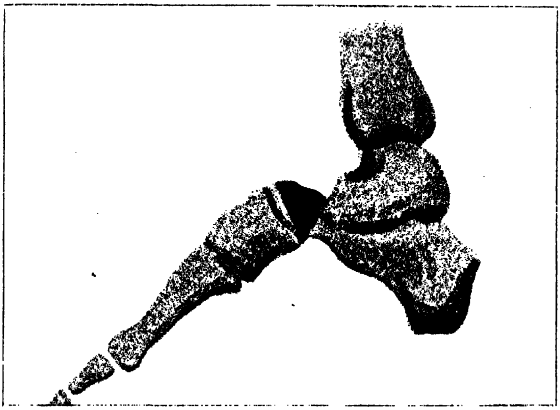

FIG. 264.—Robert Jones' Operation for Paralytic Talipes Calcaneo-Cavus, illustrating the first stage in operative procedure. Removal of a transtarsal V-shaped section of bone (Robert Jones).

(or support) should be used for a year or more, when it may be replaced by a shoe to hold the foot in slight equinus."

Whitman had, up to 1907, performed this operation in upwards of fifty cases, and regards it as the best form of treatment for acquired talipes calcaneus.

B. Robert Jones' operation.[1]—This surgeon advises restricting it to children over eight years of age. It is applicable for two conditions: (*a*) when the paralysis of the calf muscles is complete, (*b*) when some power remains in the calf muscles.

(*a*) For acquired calcaneus when the paralysis of the calf is complete. It is done in two stages, four weeks intervening.

"Stage I.—Divide the plantar fascia, if contracted, and wrench

[1] *Amer. Jour. Orth. Surg.* vol. v. No. 4, April 1908.

with the hand or instrument. Make an incision down to bone about three inches in length on the inner side of the foot, the

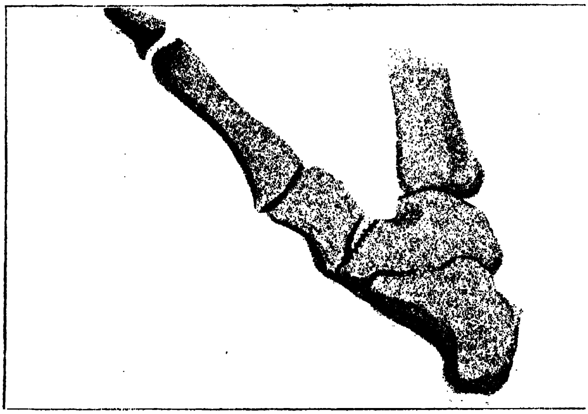

FIG. 265.—The position of the foot at the completion of the first stage of treatment (Robert Jones).

centre being opposite the angle of convexity. With a periosteum elevator separate the soft structures from the tarsus above and

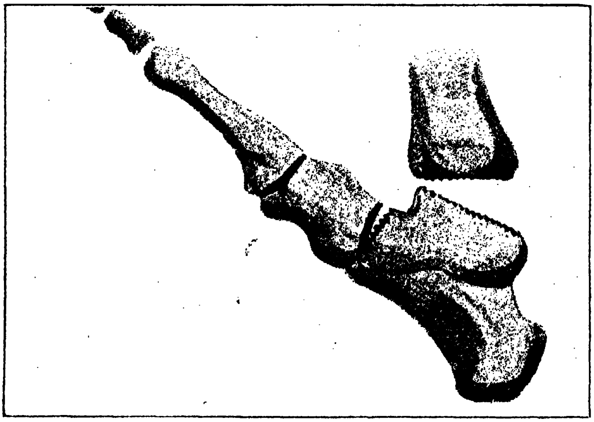

FIG. 266.—The second stage of operative treatment by Arthrodesis at the ankle (Robert Jones).

below from the inner to the outer side. Remove a transtarsal V-shaped section of bone (Fig. 264). If there be valgoid deformity, let the section be wider on the inner than on the outer side. Suture and obliterate the cavus deformity by extending the foot, which

is now bandaged to the tibia, the calcaneous deformity being now apparently much increased (Fig. 265).

"Stage II. (four weeks later).—Make a longitudinal incision at the back of the heel, the centre being opposite the ankle-joint. Open the joint and take a wedge from the astragalus sufficiently large to be accurately obliterated when the foot is brought to the right angle. Denude the tibia and fibula of cartilage (Fig. 266). The foot should be brought to the right angle and fixed immovably until the union is complete.

(*b*) "When some power remains in the calf-muscles. Stage I.

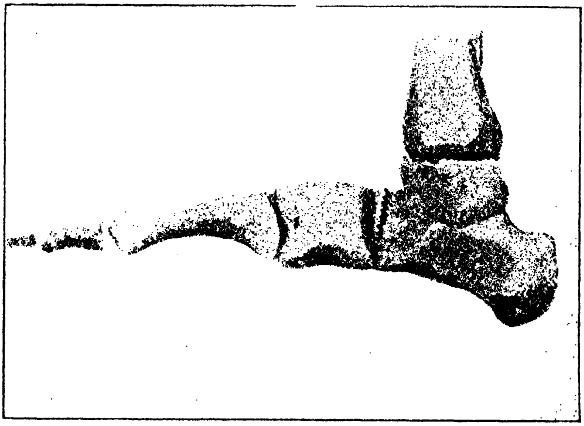

FIG. 267.—The position of the foot at the completion of the second operation (Robert Jones).

as before. Stage II.—Shorten the capsule (of the ankle); shorten the tendo Achillis; remove a skin-flap [1] (from the posterior aspect of the lower part of the leg); massage the gastrocnemius. In this case it is not advisable to remove bone." "In older subjects it may be necessary, when removing a wedge, to incise the outside as well as the inside of the foot."

As a rule, if the calcaneus is at all marked, the radical operations of Whitman or Jones are indicated.

[1] Mr. Jones evidently means "remove a lozenge-shaped portion of skin and subcutaneous tissue on the lower part of the back of the leg." Whilst the result of the operation is to give a shapely foot, we should like to have Mr. Jones' opinion as to whether progression on it is comfortable or not. There appears to be the probability of rather a "wooden" foot resulting.

Talipes Calcaneo-Valgus and Calcaneo-Varus

Although acquired valgus and varus have not yet been described, it will not be amiss to allude in this place to those rarer and compound forms, calcaneo-varus and valgus.

The paralytic form of talipes calcaneo-valgus is not uncommon. Of 903 of our cases of talipes, 36 were acquired calcaneo-valgus.

In *talipes calcaneo-varus* the heel is depressed and the inner border of the foot is concave. Hitherto we have met with but three examples of the paralytic variety, and with two cases of the congenital form.

The peculiar twist in both these forms of club-foot renders them somewhat difficult to treat. The main deformity of calcaneus often causes trouble in treatment, and unless the accompanying varus and valgus are slight, the foot does not afterwards present a very shapely appearance. Sufficient indications for treatment are given under the headings varus, valgus, and calcaneus.

Talipes Varus

In many of the cases of so-called talipes varus, the tendo Achillis is contracted, hence such cases should be styled equino-varus. Pure talipes varus is rare.

Causation—

(*a*) Infantile paralysis where the peronei alone are affected.

(*b*) In severe forms of the same disease, where all the muscles of the leg except the tibialis anticus and posticus are affected—an unusual form.

(*c*) One form of progressive muscular atrophy (peroneal paralysis—Howard Tooth), in which the peronei muscles are affected very early (*vide* vol. ii. section x.).

(*d*) As a congenital affection, and giving rise to "pigeon-toe."

(*e*) After burns on the inner side of the leg and foot, the foot being drawn to that side.

(*f*) After rupture or accidental section of the peronei muscles.

(*g*) Injuries to the sciatic, external popliteal, and musculo-cutaneous nerves. A striking form is sometimes seen after reduction of congenital dislocation of the hip (p. 206). Another cause is pressure on the external popliteal nerve by splints or bandages, as it winds round the neck of the

fibula. Accidental wounds in this situation, section of the external popliteal nerve in severing the biceps tendon, removing an exostosis from the head of the fibula, or a sequestrum from the popliteal space, may be responsible for traumatic talipes varus.

(*h*) Occasionally varus is seen in spastic paralysis, and may be simulated by hysteria.

(*i*) In relapse from congenital equino-varus, the varus is often the chief feature of the deformity.

The *general appearances* of the foot are characteristic. The foot is adducted and inverted, the toes pointing inward; the arch is increased and the patient walks on the outer edge of the foot, whilst the heel comes to the ground at the same time as the heads of the metatarsal bones. In this situation numerous corns and false bursæ are found. In congenital cases there is little or no wasting of the muscles, whilst in the paralytic cases wasting, shortening, and coldness of the limb are well marked, and there are neither the transverse nor longitudinal furrows in the sole, characteristic of the congenital form.

The morbid anatomy is described in the chapter on equino-varus. There, too, the *treatment* of varus will be found detailed. It is only necessary to summarise it in this place.

1. In infants, when the deformity can be nearly or entirely reduced by the pressure of the hand, manipulation and the use of retentive apparatus are called for. Later, a walking instrument with a varus T-strap is necessary. If there is rotation inward of the bones of the leg or at the knee-joint, the walking apparatus should be carried up to the thigh, or to the pelvis if inversion is persistent. A tin-shoe for night-wear is advisable.

2. Cases which resist attempts, made with the hand, to reduce the deformity require tenotomy of the tibialis anticus and posticus, of the plantar fascia, and section of the internal lateral ligament of the ankle. They are then placed in a retentive apparatus—either the malleable iron splint, Scarpa's shoe, or plaster of Paris—and manipulated frequently. When the deformity is fully reduced, walking apparatus of the same kind as in the first degree should be ordered.

3. Resistant cases can be reduced by tenotomy, fasciotomy, and syndesmotomy, followed by wrenching either with the hand or with Thomas' apparatus.

Tarsotomy and tarsectomy are called for (1) when the patient

is an adolescent or adult; (2) when the treatment under headings 2 and 3 has failed after thorough trial; (3) when there remains no hope of reducing the deformity by less severe means. Phelps' open operation has been done in these cases, but inasmuch as it is an operation on the soft parts alone, it cannot overcome distortion of the bones.

TALIPES VALGUS

Synonyms—French, *Pied bot valgus, Pied plat*; German, *Plattfuss.*

Here it is proposed to deal with pes planus and talipes valgus due to the following causes, viz. the spastic, paralytic, rachitic, traumatic, and the so-called pathological, whilst the subject of the painful flat-foot of adolescents and adults will be reserved for a future chapter.

Definition.—In pes planus there is merely dropping of the arch; in talipes valgus not only is the arch dropped, but the foot in front of the medio-tarsal joint is also twisted, so that the inner border is lowered and convex, and the outer is raised and concave, the sole of the foot looking somewhat outward.

Pes Planus.—In infants the sole of the foot is always nearly flat, on account of the presence of a large amount of fat in that situation, and the small size of the tuberosities of the os calcis. The latter develop from the stimulus of walking, acting on the long and short muscles of the foot. A state of flat feet is common amongst certain races, especially the Jewish, Negro, and Kabyle, and it is hereditary. It is a persistence of the normal state of the feet at birth. Pes planus is very frequently seen in epileptics.

Acquired pes planus is met with in those who walk bare-footed, and we have noticed that people who walk about the house in thin slippers, or with none at all, lose the arch of the foot, and so do children who use flat sandals. Rédard states that he has often observed pes planus in those afflicted with congenital sub-luxation of the hip, and when the deficiency is unilateral the planus is on the affected side. Adolescents with long thin feet, "long-waisted in the feet," are particularly liable to develop pes planus if they stand much or carry heavy weights. The condition of the feet may remain as planus, or it may pass into spurious valgus. Rheumatism and gout are associated with loss of the arch, and the sole becomes flat.

Acquired Valgus.—Apart from the common flat-foot of adolescents and adults, acquired valgus is not a common deformity.

Appearances in Acquired Valgus.—In most varieties there is

some eversion of the foot, with falling of the arch, flattening of the inner border, and some concavity of the outer border of the foot. In congenital valgus the deformity of the foot is complex from the first. Eversion exists at the ankle and medio-tarsal joints. In spastic valgus, and in other forms of long standing, some eversion sets in eventually. In paralytic and rachitic cases, it undoubtedly arises from the weight of the body being borne mainly on the inner margin of the foot. Structural shortening of the extensor communis digitorum and peronei results, so that the outer border is raised from the ground and the sole is everted. In all cases the internal malleolus is unduly prominent, as are the head of the astragalus and the tuberosity of the scaphoid. The child is then said to have "its inner ankle growing out." The foot is elongated, and assumes a "boat or canoe shape."

The essential anatomical feature of the deformity is relaxation of the internal lateral ligaments of the ankle, of the calcaneo-scaphoid, astragalo-scaphoid, and scapho-cuneiform ligaments, and of those uniting the cuneiform and three inner metatarsal bones. In this relaxation the inner and middle parts of the plantar fascia participate, so too do the short muscles of the great toe. In the outer longitudinal arch of the foot the ligaments, muscles, and fasciæ are proportionately contracted. The bones are altered in position, but rarely in shape, except in long-standing cases. The head of the astragalus is directed downward and inward, the scaphoid is rotated so that the tuberosity is brought downward and inward, and there is a space between the two bones; whilst the inferior surface of the calcis is twisted slightly outwards. Bursæ and corns, and even perforating ulcers form over the bony prominences on the inner margin, and cause great pain.

In the section on talipes arcuatus that peculiar form "pied creux valgus," or valgus with increase of the arch, has been alluded to. It is said by Duchenne to occur in spastic valgus, and to be due particularly to exaggerated action of the peroneus longus. This curious form has been closely studied by the French surgeon, and he says its characteristics are:—

1. An increase of the plantar arch, with lowering of the heads of the metatarsal bones.

2. A diminution of the transverse measurement of the fore part of the foot, especially at the heads of the metatarsal bones.

3. A torsion of the front part of the foot producing oblique folds on its plantar aspect.

4. A displacement outwards of the calcis from the astragalus.

5. Considerable prominence of the tendon of the peroneus longus below the external malleolus.

Paralytic Valgus.—Of pure valgus arising from infantile paralysis we have met with but few examples. It is stated that paralytic valgus assumes two forms:—

(*a*) In which the peroneus longus is not affected; and then the appearance of the foot is that of valgus, *i.e.* the foot as a whole is abducted, but the arch is retained or increased.

(*b*) In which the peroneus longus is paralysed, and then the arch drops, and the foot is abducted by the peroneus brevis and extensor communis digitorum, but is not everted.

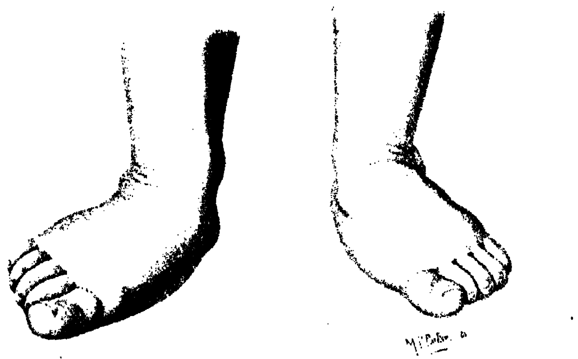

FIG. 268.—Rachitic Talipes Valgus in a child aged 18 months.

It is interesting to notice that in the same patient one frequently sees varus or equino-varus in one foot, and valgus or equino- or calcaneo-valgus in the other, the varoid deformity being in the right, and the valgoid in the left foot, or *vice versa*.

In paralytic valgus of the less severe degrees the tibialis anticus alone is affected, but in the more severe degrees the tibialis posticus and the muscles of the calf are implicated as well; and then calcaneo-valgus results. The affected muscles do not respond to the interrupted and the constant current, and are found to be in a state of fatty or granular degeneration.

The symptoms are similar to those of congenital valgus, except that in early cases the foot is not everted, and there is the peculiar relaxation of the muscles accompanying infantile paralysis, together with wasting, coldness, and blueness of the limb. In addition, on

the outer side of the crest of the tibia a groove is seen which corresponds to the atrophied tibialis anticus. The extensor communis digitorum and peroneus tertius are tense.

Rachitic Valgus.—Among the many cases of rachitis one does not find so many instances of valgus as one might expect. It is probably due to the fact that rickets takes children "off their feet," and there is consequently in but few cases yielding of the plantar arch. When it does exist it is a well-marked deformity (see Fig. 268).

The point of importance is to remember that rachitic flat-foot may and does persist and leads to painful flat-foot in adult life. We have had no opportunity of dissecting a rickety flat-foot, but the adult rachitic skeletons in museums show considerable alteration in the shape of the bones. It is frequently associated with genu valgum.

Traumatic Valgus.—After Pott's fracture, dislocation at the ankle, or severe sprain with rupture of the internal lateral ligament, the foot may be permanently carried outwards, and after a time the arch of the foot gives way. Numerous examples of this have come under our notice, and the cases are tedious, painful, and not easy to remedy. The greatest care should be taken in putting up a Pott's fracture, and the foot should be brought into the inverted or over-corrected position, so as to anticipate this deformity.

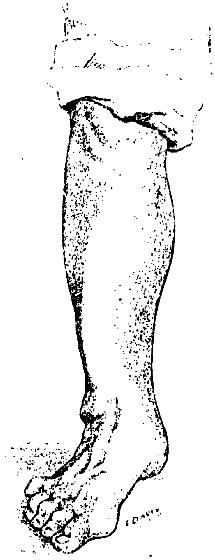

FIG. 269.—Spasmodic Eversion of the foot after injury to the fibula.

The accompanying Fig. 269 is taken from a patient who came to my Out-patient Clinic.

Rare cases of separation of the epiphyses of the tibia or fibula are recorded, followed by varus or valgus.

Spastic Valgus.—Instances of this are comparatively rare. The deformity is due to convulsions in young life.

Hysterical Valgus.—We have met with two examples of this in growing girls.

Valgus associated with other Causes.—Acute periostitis and osteomyelitis, interfering with the growth at the epiphysial line, cause inequality in the length of the two bones. Accordingly as the tibia

or fibula is affected, so varus or valgus results. The following interesting case may be quoted:—

CASE 6.—*Congenital Syphilis, Shortening of left leg, Valgus in the right foot.*—Florence G——, aged 15 years, came to us complaining of pain in the right foot. She said that when she was about 1 year old there was, from her mother's account, considerable stiffness of the left knee.

On examination, there are scars about the mouth, leucomata in the left cornea, and the central incisors are notched. The left leg is ½ inch shorter than the right, and just above the lower extremity of the left femur a distinct thickening is felt. The right foot is valgoid.

In this case it seems that a syphilitic epiphysitis occurred at the lower end of the femur, interfering with the rate of growth of the bone, hence the shortening on the left side. As a consequence, more weight has been borne upon the right side, and the foot has developed valgus.

Prognosis of Acquired Valgus.—This must necessarily vary with the cause, the amount of deformity, and the length of time it has existed. In traumatic and rachitic valgus the outlook is not favourable; while in the paralytic form much recovery of power may be looked for in early cases. And, in late cases, the form of the foot can be restored, and much assistance given by operative means and supports, so that the patient is able to go about comfortably.

The Treatment of Talipes Valgus.—Paralytic valgus is treated by tenotomy of the contracted tendons, tendon transplantation, exsection of lozenge-shaped portions of skin on the inner side of the foot, arthrodesis in suitable cases, and the use of supports. Treatment is fully dealt with in the section on "Paralytic Deformities."

In spasmodic valgus the rigidity of the muscles is such that exsection of an inch or more of the peronei tendons is called for, with section of the extensor communis digitorum.

Rachitic cases merely require suitable support and constitutional remedies.

Pathological valgus, or that variety which is a sequel to acute and tuberculous arthritis of the ankle, or ostitis of the bones of the foot, demands considerable thought before the foot is interfered with. Much will depend upon the disease being entirely quiescent; the freedom of the tendons in their sheaths, both structures being only too often involved; and upon the patient's wish for improved powers of locomotion.

In traumatic valgus, particularly that following Pott's fracture, much improvement may be obtained by active and passive exercises, sedulously carried out, by forcible rectification, and placing the foot in plaster. Section of the contracted tendons on the outside of

the leg is often necessary as a preliminary measure, and it may be done when there exists much stiffness at the ankle-joint.

Talipes Equino-Valgus

After the references which have been made to the frequent association of equinus and valgus in both congenital and paralytic club-feet, and the separate description given of both of these conditions, it is unnecessary to allude further to them.

Acquired Talipes Equino-Varus

Acquired equino-varus is paralytic, traumatic, and articular. Paralytic equino-varus is due to acute anterior poliomyelitis, multiple neuritis, and injury to the external popliteal nerve. Traumatic equino-varus is the result of fractures, dislocations, or separation of the epiphyses at the lower ends of the tibia and fibula. Inflammatory processes in the ankle and tarsal joints, whether rheumatic, gouty, tuberculous, or syphilitic, are responsible for the articular forms of equino-varus.

The rarer causes are hysteria,[1] fractures in the neighbourhood of the ankle, and dislocations. Infantile paralysis affecting the peronei and the extensor muscles (the tibialis anticus often excepted [2]) leaves full scope for the action of the opposing muscles. Hence the raising of the heel and the inversion of the sole.

Fig. 270.—Spastic Talipes Equino-Varus in a woman, aged 35 years.

The latter position is due to the powerful traction of the tibialis

[1] See Walsham and Hughes, *op. sup. cit.* fig. 204, p. 328.

[2] In some cases the extensor proprius pollicis escapes, and extension and flexion of the great toe are normal.

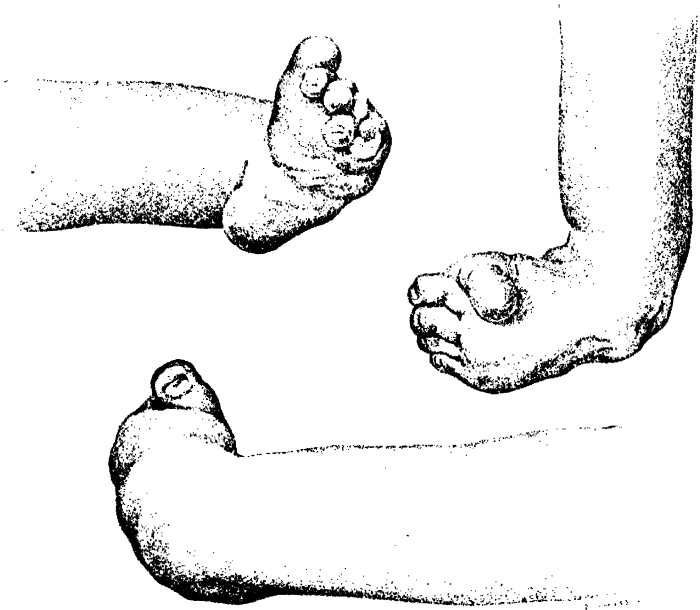

FIG. 271.—Extreme Spastic Talipes Equino-Varus in a woman, aged 44 years.

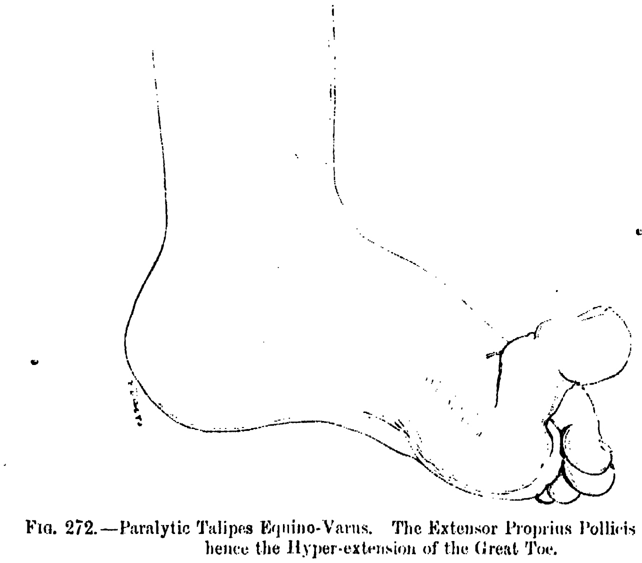

FIG. 272.—Paralytic Talipes Equino-Varus. The Extensor Proprius Pollicis has escaped, hence the Hyper-extension of the Great Toe.

posticus, flexor longus digitorum and pollicis, which pass behind the internal malleolus obliquely into the sole to their attachments. In

FIG. 273.—Paralytic Talipes Equino-Varus.

spastic paraplegia the adductors and invertors of the foot are excessively contracted, as in the thighs and elsewhere. A rare form of

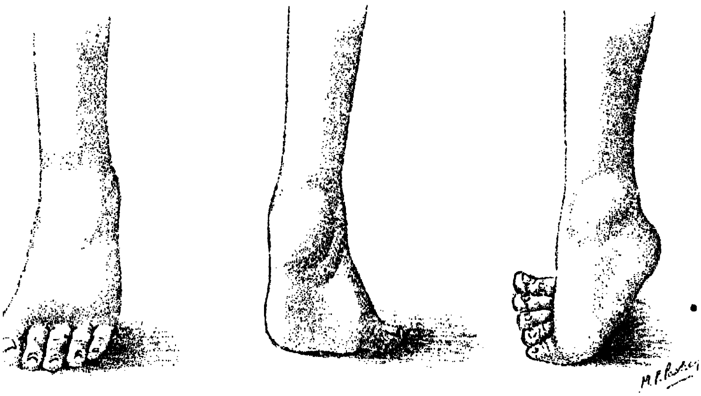

FIG. 274.—Three views of a foot affected by Paralytic Talipes Equino-Varus.

progressive muscular atrophy called peroneal paralysis affects the peronei and the extensor muscles, and results in talipes equino-varus

(Charcot, Tooth). Many cases of equino-varus due to spastic paralysis (vol. ii. sect. x.) come under the notice of orthopaedic surgeons. In some instances the nerve lesion has appeared subsequently to birth.

Morbid Anatomy.—The anatomy of paralytic equino-varus can be readily understood by reference to the separate descriptions of equinus and varus (pp. 333 and 353).

Prognosis.—Cases of paralytic equino-varus, when seen early, are readily amenable to treatment, and the deformity can be relieved by tenotomy, tendon grafting, and transplantation and nerve anastomosis.

FIG. 275.—Spastic Talipes Equino-Varus in a boy, aged 17 years.

The prognosis of the spastic form is not so good. Like congenital cures, they show a tendency to relapse.

Treatment.—Acquired equino-varus is treated on the same lines as the congenital form, and in some cases tendon transplantation and arthrodesis are called for.

HAMMER-TOE

Synonyms—French, *Orteil en marteau, Orteil en Z, Orteil en cou de cygne, Orteil en griffe*; German, *Hammerzehe.*

Definition.—A deformity usually affecting the second toe, and consisting of dorsi-flexion of the first phalanx, plantar-flexion of the second, and extension of the third phalanx.[1]

[1] Hammer-toe must not be confused with the contracted and claw-like toes met with in various forms of talipes. In the latter cases *all* the toes are affected, and the following forms of contraction are present:—

(*a*) In talipes equinus all the toes may be dorsi-flexed at the metatarso-phalangeal

Ætiology.—1. *Congenital.*—A small proportion of the cases are distinctly congenital. In these instances the second toe is

FIG. 276.

FIG. 277.

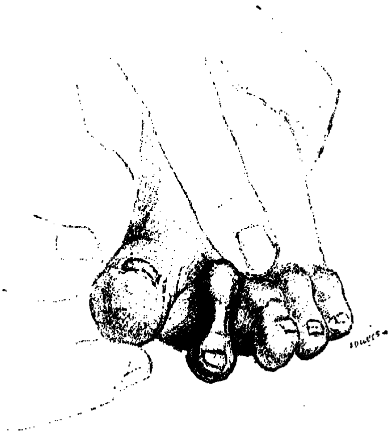

FIG. 278.

Three Views of a case of Hammer-Toe.

usually affected, and in both feet. In the same patient congenital

joint, and plantar-flexed at the first interphalangeal joint. A condition similar to this is met with in talipes arcuatus and plantaris.

(*b*) The toes may all be plantar-flexed from the metatarso-phalangeal joint, so that the dorsal surface of the toes is in direct contact with the ground.

contraction of the fingers, especially of the fourth and fifth, may be seen.

2. *Heredity.*—Of all the deformities to which the foot is liable, this is the one in which heredity is most marked. Mr. William Anderson has traced it in at least a fourth of the cases which had come under his notice; and in the *Lectures on the Contraction of the Fingers and Toes*[1] he alludes to an instance in which the deformity had occurred in four generations.[2] I have met with two examples in private practice of its perpetuation through three generations.

3. *Acquired Causes.*—In many people the second toe is longer than the first, and by some this is believed to be the normal state. Whether the first or second is the longer matters little, if tight and pointed boots be worn, so far as the production of hammer-toe is concerned. In either case the great toe, not having sufficient room, is subluxated outwards and the other toes become clawed. As the displacement of the great toe persists, it rides over the second toe, and the second and third phalanges of the latter being maintained in constant plantar flexion, adaptive shortening of the long tendons and the lateral and glenoid ligaments follows, with hyper-extension of the first phalanx.

The Appearances of Hammer-Toe.—On the dorsal aspect of the first interphalangeal joint a painful corn is frequently present. Beneath this is a bunion, which from time to time inflames and suppurates. On the under surface of the joint a deep groove is noticeable. The skin is contracted, and at the bottom of the groove the long flexor tendon can be felt. The first phalanx is in a state of extreme dorsal flexion, so that the head of the metatarsal bone is uncovered below to about half its extent. The second phalanx is always plantar-flexed, while the third may be either plantar-flexed, dorsi-flexed, or in a line with the second. As a result of the squeezing of the end of the affected toe downwards, its tip is often broad and flat, hence the term "hammer-toe."

The second toe is in the majority of cases affected, and in both feet, but to a variable degree. I am inclined to think that the deformity is more common in women than in men.

[1] *Lancet*, vol. ii., 1891, p. 213.

[2] Mr. Warrington Haward showed six dissected specimens at the Pathological Society in 1893. These toes had been amputated on account of the pain they caused. Mr. Haward was unable to accept the theory of ill-fitting boots to explain all the cases. "Many were distinctly hereditary, and occurred in neurotic people" (*Lancet*, 6th May 1893).

Morbid Anatomy.—To Shattock and Adams must be ascribed the credit of first having correctly described the anatomical conditions in an advanced case. Whatever may have been the original cause, the great obstacle to reduction is found to be in the shortened lateral ligaments and the contracted glenoid ligament. The flexor and extensor tendons are undoubtedly contracted, but division of them is not sufficient to remove the deformity. The lateral ligaments must be severed. As a result of the displacement, neither the lower part of the head of the metatarsal bone nor the upper half of the head of the first phalanx is covered by the bone articulating with it, and the cartilage of the uncovered portion of bone is thin and atrophied. On account of inflammation extending from the bursa, ankylosis between the first and second phalanx has been met with.

Treatment.—In slight cases, attention to the boots and the various measures for remedying outward displacement of the great toe detailed on p. 714 are of value, especially if care be taken to straighten the affected toe several times night and morning. By fixing, at night, a malleable iron splint suitably bent to the sole and to the affected toe, the condition will often be improved. Ernst makes a useful T-spring for slight cases (Fig. 279). This is also of service after operation.

FIG. 279.—T-spring for Hammer-Toe. The Spring is applied to the Sole of the Foot and to the under Surface of the affected toe, which is extended upon it after operation.

Operative.—In cases of medium severity, forcible reposition with the fingers under an anæsthetic is sometimes successful. A distinct snap or crack is felt indicating rupture of the lateral ligaments. If the shortened skin prevents complete restitution of the toe, the skin may be divided by a V-shaped incision.

Division of the Ligaments.—W. Adams performed this operation subcutaneously for several years with much success. I have also treated a large number of cases on this plan with the best results.

Subcutaneous section is performed, under all aseptic precautions, in the following manner:—An assistant holds aside the first and third toes, and the surgeon, steadying the second toe with his left hand, enters a fine, narrow-pointed, strong-backed knife into the mid-point of the groove on the under aspect of the first interphalangeal joint. Passing the knife upwards, beneath the skin, and avoiding the digital arteries and nerves, the edge of the knife is turned toward

the bone, and the lateral ligaments severed. By continuing the division on the under aspect of the joint, the long tendon and the glenoid ligament are divided. Without removing the knife from the skin puncture, it is passed down to bone through the remaining lateral ligament. After free division of the ligaments and tendon, the toe can be brought into good position. If not, a little force suffices to rupture any of the ligamentous fibres which may have escaped division. In some cases it is as well to sever

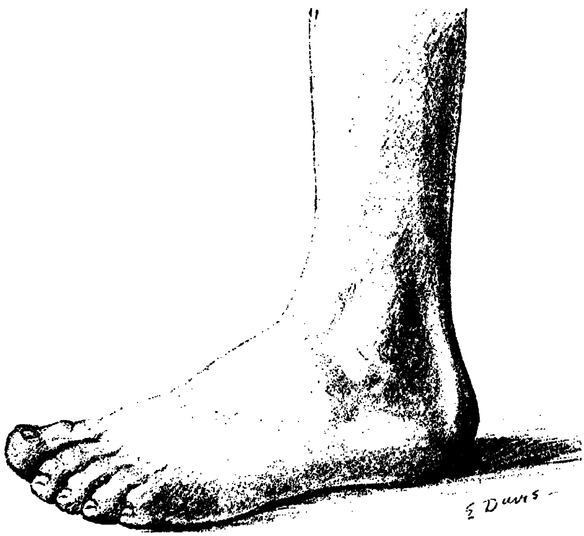

FIG. 280.—The same case as in Figs. 276-278. The Hammer-Toe Deformity is completely relieved.

the contracted extensor tendon as well. Should the toe, however, not come into good position, the puncture on the under surface may be enlarged into a transverse incision, and the head of the first phalanx protruded and removed with bone forceps.

After the operation and dressing, the toe is placed in the corrected position on a malleable iron splint, until the wound is healed. A T-splint is then worn for some time until the toe shows no disposition to return to its former state.

Complete excision [1] of the joint by a lateral incision is practised.

[1] Acting on the suggestion contained in Mr. Anderson's Lectures, Surgeon-Captain Rowan successfully removed the heads of the first phalanges in a bilateral case in which tenotomy had been tried and failed (*Brit. Med. Journ.*, 10th June 1893).

and cures the patient; saving, too, a considerable amount of time in treatment. Amputation is an unnecessary and barbarous mutilation. If the second toe is removed early in life, the great toe is pressed outward by the boot, and a bunion forms.

Lateral Deviation of the Toes

This affection is often of acquired origin, and is due to the cramping of the feet by boots.

In infancy and early childhood the affection can be treated by manipulation and by splints, or by a leather sole-plate, so arranged that each toe can be tied down in its place and held straight. The child should also wear digitated stockings and shoes of sufficient breadth. Operation is very rarely called for in children. In adults, digitated stockings and broad boots ought to be worn by day and sole-plates at night, and if one toe becomes fixed beneath its neighbour, section of the lateral ligaments and tendons is advisable; amputation is, however, rarely necessary.

A frequent condition met with is overriding of the fourth toe by the phalanges of the fifth toe, which becomes gradually dorsiflexed and deviated inwards. Simple section of the tendon in these cases is useless, and the small operation the author practises is as follows:—An incision is made starting from the web between the fourth and fifth toes and carried backward for three-quarters of an inch. A second incision is made starting from the outer side of the base of the first phalanx of the little toe and carried backward to join the first, so that a triangular flap is formed. This flap is dissected up, and the knife is then passed through the tendons and ligaments into the metatarso-phalangeal joint of the little toe. It can then at once be brought into place. One suture is inserted at the tip of the flap and across the gap and holds the flap loosely in place, but the suture should not be drawn tightly, otherwise contraction of the skin occurs later. A wound of considerable surface is thus left to granulate. During healing, the toe must be kept in place by a small soft iron splint.

Contracted Toes

This condition is usually acquired. It arises from narrow and bad boots, and particularly from short ones. It is also seen in infantile paralysis from adaptive shortening of the extensor longus

digitorum tendons in spastic paralysis and Friedreich's disease. Duchenne advanced the theory that when the first phalanges are hyper-extended, and the second and third flexed, there is paralysis of the lumbricales and interossei, and founded his views upon electrical observations and reactions, but, so far as we know, did not substantiate them by post-mortem observation. In the absence of such proof his theory cannot be generally accepted. In some forms of nerve disorder, notably progressive muscular atrophy, the lumbricales and interossei of the feet may or may not be affected. And in talipes equinus from anterior poliomyelitis, the small interdigital muscles often escape, and then the contraction of the toes is due to adaptive shortening of the long extensor muscle and tendons; for it is quite clear that paralysed or partially paralysed muscles are quite as capable, if not more so, of undergoing contracture.

Treatment.—Having ascertained the cause, if the condition is not a very troublesome one, efforts are to be made to straighten the toes by passive manipulation, and wearing a sole-plate with a separate stall for each toe. Usually the great toe escapes contraction, but, if the long extensor is involved, the first phalanx of this digit becomes hyper-extended, and the second abruptly flexed.

If the simpler measures are not effective, then the extensor tendons are severed just above the metatarso-phalangeal articulations, and the flexor at the first interphalangeal joint, where too the lateral ligaments can be divided. After the wounds have healed, the toes are gradually straightened on a sole-plate. Digitated stockings and broad boots are advisable when walking is commenced.

Corns

Corns are due to hypertrophy of the skin papillæ, one or more of which become enlarged and form the centre or core. The epithelium on the papillæ grows more rapidly than elsewhere, and projecting above the general level is liable to pressure, which irritates the nerve-endings in the subjacent papillæ and causes pain. Around the centre, the surface-epithelium is heaped up and forms the outer ring of the corn, and the papillæ beneath, being enlarged, are now subject to inflammation from pressure. Several central papillæ may be hypertrophied, and the corn becomes a papilloma.

Corns on the feet are clinically of two kinds, the Infective and Non-Infective:—

(*a*) *Infective Corns.*—The writer has met with several cases of this type. Not only do they appear in places where pressure arises, but after a time they form in spots, such as the under surface of the arch of the foot, where little or no pressure is made. One factor influencing their spread appears to be bleeding after picking or wounding the original growth. In one instance we counted no less than fifty-one on the right foot and twenty-nine on the left after bleeding from the original corn had been caused by a chiropodist. The term infective is a little far-fetched, but it serves to emphasise the points that the multiplication of the corns is not dependent on pressure, but is directly associated with hæmorrhage from previously existing corns. In some cases we have seen them not only on the feet, but on the hands and face, yet always in larger numbers on the feet, where they have appeared originally. Doubtless they are rather warty than keratinous. Occasionally the condition is hereditary.

Treatment.—This variety is not suitable for any form of cutting operation. The more the parts bleed, the greater the liability to further infection. The writer has found that the best way to treat them is to use a fine glass pencil, and to ring round the centre with nitric acid, and then to stab the wart or corn itself with the point of the glass rod dipped in nitric acid. Then, the part is fomented with boracic acid lotion, and in ten to fourteen days the papilloma and adjacent epithelium come away, leaving a healthy surface of skin.

Sometimes these infective corns appear in smelling feet, and perhaps they are of bacterial origin.

A word here as to *smelling feet,* which are due to the multiplication of putrefactive bacteria. The sufferer is to wash his feet twice daily with soap and water, and then bathe them with chromic acid lotion, gr. ij.-℥j., dry them carefully, and sprinkle the feet with the following: Acidi salicylici, gr. ij.; Pulv. talcis, ℥j. It is advisable for the patient to put on clean socks twice a day, and wear shoes and not boots.

(*b*) *Non-Infective Corns.*—They are due to pressure alone and are symptomatic. Thus a row of corns beneath the heads of the metatarsal bones leads us to examine for contraction of the plantar fascia or of the tendo Achillis, particularly of that little-recognised form, the right-angled variety. Corns on the dorsal aspect of the toes mean short and tight boots and contracted toes. A corn on the sole beneath the head of a metatarsal bone indicates dropping

of that head, and if present beneath the fourth metatarsal head is generally associated with anterior metatarsalgia or Morton's disease. Frequently the spasmodic pain is ascribed to the corn, and not to the pressure on the digital nerve by the dropped metatarsal head.

A corn is sometimes found over the false bursa of a bunion, or in talipes varus over the base of the fifth metatarsal bone, or over the cuboid. In severe flat foot a corn develops over the prominent scaphoid, and when exostosis of the tuberosities of the os calcis exists, corns develop upon the under surface of the heel. Any irregularity of the inside of the sole of the boot or of the "upper" will sometimes start a corn, particularly in those whose parents have suffered in the same way or are gouty.

Treatment.—It is useless to treat the corns primarily; the exciting cause must be discovered and removed. Then the corns will either disappear spontaneously or the well-known Salicylic collodion (Acidi salicylici, gr. v.; Ext. cannab. indic., ʒss.; Collod. flexile, ℥j.) may be applied several nights in succession after soaking the feet in hot water.[1]

Pain in the Soles of the Feet

After an illness, when the feet have not been used for a considerable time, the soles are soft and tender, particularly if desquamation has taken place. The tenderness, however, passes away as the patient regains strength and is able to walk.

In rare instances and in emaciated people of a neurasthenic type, particularly in women, the fatty subcutaneous structures in the soles disappear entirely, so that portions of the bones, especially of the heel and the heads of the metatarsal bones, almost come in direct contact with the ground or with the inner surfaces of the soles of the boots. The pain and discomfort are of such a degree as to preclude the patient walking. In one instance the author succeeded in overcoming the difficulties presented by the case by having the inside of the sole-leather lined with a layer of spongy rubber half an inch thick; and in another case he devised a "glycerine-bed" on the same principle as a water-bed. In both cases the result was most gratifying to the patients.

When flat-foot is present, frequent complaints of pain in the soles are made. In some instances it arises from stretching of the

[1] Before treating a corn in an elderly person, the urine should be tested for sugar. If it is present, great caution must be exercised.

plantar fascia, muscles, tendons, and ligaments. In other cases it may be due to pressure on the plantar nerves.

The opposite conditions of excessive arching of the foot, pes cavus, talipes arcuatus, and plantaris are frequently painful, on account of the tension of the fascial bands on standing; and relief is obtained when the fascia is divided.

Tearing and rupture of the plantar fascia are always accompanied by pain on standing, which subsides after rest and healing of the part.

Many other local conditions of the feet are painful, and we may enumerate diffuse lipoma, bony outgrowths, metatarsalgia, and spur-like formations on the tuberosities of the os calcis.

General conditions, such as rheumatism and gout, are responsible for the neuralgia in some instances. We meet with rheumatic nodules and with gouty thickening of the fascia. Finally, Raynaud's disease, endarteritis obliterans, arterial sclerosis, erythromelalgia, and dysbasia angio-sclerotica are frequently causes of painful feet.

The *treatment* involves recognition of the causation, and using remedies as described under the appropriate headings.

During the past ten years some examples of an affection, hitherto undescribed, have come under my notice. The trouble, although a slight one, yet causes considerable difficulty and pain in walking, and from its position mistakes easily arise in diagnosis. I append notes of two cases:—

Case 7.—A hospital nurse, aged 25 years, was admitted to Westminster Hospital on 24th May 1906. She had been nursing for nine months. Three months previously she experienced aching pains in the soles and inner sides of the feet. The pain was worse on rising in the morning and for about an hour afterwards, but it continued to trouble her for the whole day. Almost instantaneous relief was obtained on lying down or resting the foot, but the pain came on again on walking. On examination, looking at the feet on the inner side and just below the sustentacula tali, an oval swelling was visible on each foot. The growths encroached on the weight-bearing surface of the feet; in size they measured 1 inch by $1\frac{1}{2}$ inches. Their characters were those of indolent growths, moderately well defined, and without signs of inflammation over them. They were painful to the touch and particularly so to deep

[1] A. H. Tubby, *Lancet*, 26th September 1908, p. 937. Art. "Painful Lipoma of the Foot."

pressure. The feet were not flat in the ordinary sense of the word. From an experience of similar cases the swellings were diagnosed as diffuse lipoma. An operation was undertaken, and when the swellings were incised they were found to be of a fatty nature. They were not encapsuled; but the lobules of fat of which they were composed were considerably larger and lighter in colour than the surrounding normal fat, so that there was no difficulty in dissecting away the whole of the growths. It was noticeable that the tumours were highly vascular and bled considerably. The wounds were closed in the ordinary way and healed without difficulty.

My friend and colleague, Dr. R. G. Hebb, made a microscopical examination, and reported that no evidence of nerve endings or of nævoid tissue was found in the tissue, which consisted entirely of fat. The patient presented herself for examination at intervals, and the growths did not recur.

CASE 8.—A girl, aged 16 years, was admitted to Westminster Hospital on 20th January 1906, complaining of pain on the inner side of the right foot, which had troubled her for a year. The pain was at its worst after walking, but not severe enough to prevent her from getting about. On examination, on the inner side of the right foot there was a round elastic swelling about one inch in diameter. The highest point of it was one inch below the tip of the internal malleolus, and the lowest point half an inch above the heel. It presented the same physical characteristics as the tumours in the preceding case, and was most prominent when the foot was forcibly dorsi-flexed. The swelling was removed, and showed the same fatty and vascular character as in the preceding case. When the patient left the hospital she was able to walk without pain.

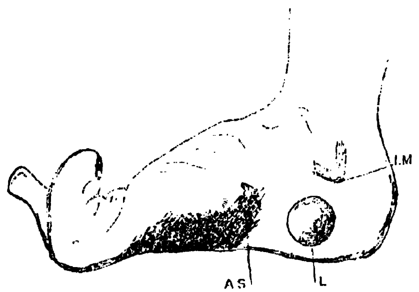

FIG. 281.—To illustrate the appearances in Case 8. The position of the Lipoma is clearly shown at L, and its relation to the inner longitudinal arch of the foot is evident. I.M., Internal Malleolus. A.S., Astragalo-scaphoid Joint. The great toe is in a state of temporary spasmodic dorsi-flexion.

These cases of acquired localised painful lipoma of the foot are clearly distinguishable from that form of "gigantism" known as congenital diffuse lipoma, where the affection is characterised by a general hypertrophy of the fatty and subcutaneous tissues, first affecting the toes or fingers, which spreads by direct continuity for a time; but, as the hypertrophy increases, isolated masses of fatty

material appear at some distance beyond the advancing edges. In time these masses become incorporated with the advancing growth. The microscopical characters of the *congenital* diffuse lipoma are entirely different from those observed in the painful *acquired* form of lipoma. In the former, while the main part of the section is occupied by fat and areolar tissue, yet the interfibrous spaces are crowded by small round cells not unlike those seen in round-celled sarcoma. Clinically the diffuse congenital form of lipoma is somewhat akin to sarcoma in that it shows an inveterate tendency to recur very rapidly after removal. In the acquired localised form no such appearances are evident, but the blood-vessels are extremely numerous and somewhat hypertrophied. In connection with their origin cases are met with, which throw some light on this point; such an one is the following, occurring in a girl, aged 17 years, which was diagnosed as angio-neuroma of the hands. In April 1907 a swelling formed on the dorsum of the right hand towards the radial side. It was situated over the first and second metacarpal bones, and appeared to surround more particularly the extensor tendon of the index finger. The growth was always extremely painful to the touch, and sometimes gave her pain even when the part was at rest. The skin over the tumour was hotter than in other parts of the hand; at the centre it was red, and there was a dark bluish discoloration around the circumference. The swelling increased rapidly whilst she was under observation for a few days previous to operation. A mass of nævoid tissue of about the size of half-a-crown was excised through a T-shaped incision. Dr. Hebb made the following report on the specimen: "It consists of fibrous and adipose tissue in which are numerous blood-vessels, the arterial walls being extremely thick." The left hand had been similarly affected in January 1907, when the girl was operated on by my colleague, Mr. Arthur Evans. In January 1908 she re-appeared at the hospital, as the angiomatous condition had re-formed on both hands. The striking feature of her case was the extreme tenderness, and the parts were so sore that it was impossible to examine them properly. Further, the swellings were hard and appeared hotter to the touch than elsewhere. An operation was undertaken by Mr. E. Rock Carling, and a considerable mass of nævoid tissue was dissected from the extensor tendons over which it had spread. Two recurrences have since occurred.

Now, in the case of acquired painful lipoma, and in the nævoid condition just described, in which fat was present, we have certain

conditions in common, namely, their excessive vascularity, the size and thickness of the vessels, and their extreme tenderness. It is difficult to account for the tenderness. It may be due to irritation of the nervi vasorum. Certainly, no nerve fibres or endings could be discovered in the substance of the growths. Whether the acquired diffuse form is due to fatty degeneration of nævoid tissue is not proven, but this possibility should be borne in mind.

We now pass on to certain clinical points. Without careful observation, the swellings due to acquired painful localised lipoma may partially fill up the arches of the feet, so that the condition can be mistaken for flat foot; but, in all the cases the writer has seen, numbering now six, the tumours have always been between the inner edge of the sole of the foot and the internal malleolus, and have not extended farther forward than the anterior part of the sustentaculum tali. In no case have they been over the scaphoid or internal cuneiform bone. The striking features about them are their slow growth and their indolence, their extreme tenderness, and their vascularity when cut into. It is also noticeable that any pressure, whether arising from an irregularity on the inside of the boot, or from the employment of a "flat-foot" pad, renders the patient completely unable to get about on account of the pain. Finally, on removal, they do not, so far as I know, recur, and in this respect are entirely different from the congenital diffuse lipoma.

Bony Outgrowths of the Foot

One common form is the projection of the scaphoid inwardly, seen in the long and flat foot of adolescence, particularly in girls. It is due to relaxation of the ligaments and subluxation inward of the scaphoid bone, and is particularly difficult to treat. Its presence often hinders the use of boots and of flat-foot pads, as the skin over the prominences frequently becomes thickened and inflamed. In such cases the writer has no hesitation in advising removal of the prominent portion of bone so as to expedite the treatment of the flat foot.

In pes cavus the bases of the metatarsal bones, particularly the first, and the cuneiforms project on the dorsum of the foot, and the skin over them becomes tender from the pressure of the boot. We shall describe the spur-like formation on the heels and exostoses on the posterior aspect of the os calcis, and we shall refer to the bony outgrowth on the inner side of the head of the first metatarsal bone

Fig. 1.

Radiogram taken from the outer side of a foot. A Bony Spur is seen in the neighbourhood of the Internal Tuberosity of the Os Calcis.

Fig. 2.

The same foot viewed from the inner side.

To face page 375.

in bunion. In rheumatoid arthritis, osseous outgrowths occur, particularly about the heads of the metatarsal bones, and are one cause of anterior metatarsalgia. Treatment of these affections depends upon their cause.

Malignant Growths on the Feet

Apart from carcinomatous growths of the skin the most usual is sarcoma, and this invades particularly the scaphoid bone. If not carefully examined, it may be mistaken for tubercular osteitis, or even for the displaced scaphoid of flat foot.

Painful Heel

It is not an uncommon affection, and arises from many causes.

When it is unilateral it may be due to standing too much on one foot, owing to a short leg. The writer has relieved several cases of this description by putting a cork sole in the boot. The heel is also tender in flat foot and Achillo-bursitis. Sometimes a false bursa forms in the fat beneath the tuberosities of the os calcis and becomes inflamed, and it may contain melon-seed bodies or even a fasciculated neuroma.[1] In pes cavus the posterior attachment of the tense fascia becomes very painful.

Examination by X-rays often shows a spur-like formation on one of the tuberosities of the os calcis, particularly the inner (Plate XXIII.), as if the attachment of the plantar fascia had undergone osseous change. Frequently a painful heel arises from excessive standing (policeman's heel), or from bruising, and in rare instances from epiphysitis, tuberculous or syphilitic, of the os calcis.

Among the general conditions associated with pain in the heel are gonorrhœa,[2] rheumatism, acute or subacute, gout, and arthritis deformans.

Treatment.—The difficulty is to be sure of the cause; so that the general condition should be carefully inquired into, and appropriate measures, with local rest and counter-irritation, succeeded by sedative applications, employed.

It is highly advisable to take an X-ray photograph of the heel,

[1] Brousses et Berthier, *Rev. de chir.*, August 1895.

[2] Baer, *Surgery, Gynæcology, and Obstetrics*, July 2, 1906, describes several cases where exostoses followed gonorrhœa, the growths beginning in the muscular insertions into the os calcis.

particularly from the lateral aspect, and a case refractory to palliative treatment will often be found to be associated with a spur-like outgrowth from one of the tuberosities; this requires removal. If no spur is present, then relief is often given by applying oleate of morphia (1 in 60) to the heel, enjoining rest of the part for a week or ten days, and making an alteration in the boot. A hard rubber pad is attached to the outside of the heel of the boot, and inside, a soft spongy pad half-inch thick is fixed. The majority of cases yield to these measures, but if everything fails an operation is advisable. A flap, with its convexity backward, is raised from the heel, and all the structures carefully examined. Any abnormality of structure is readily dealt with.

Achillodynia is associated with inflammation of the bursæ about the attachment of the tendo Achillis, and is described under Achillobursitis in Section IV.

Pain about the Base of the Fifth Metatarsal Bone

Generally, this is seen in cases of talipes varus, and is a result of direct pressure upon the part. It is also met with in Morton's disease when the peculiar inward twist of the metatarsus is present. Sometimes, without any such twist being present the small bursa beneath the peroneus brevis becomes inflamed. Fracture of the base of the fifth metatarsal bone, which generally follows sudden movements such as jumping or running, or may happen without apparent cause during walking, is answerable for temporary pain. The fracture is usually transverse, and about half an inch from the base of the metatarsal bone. This cause of the pain and swelling is often unsuspected, until revealed by a Röntgen ray photograph.

Circulatory Disturbances

CHILBLAINS

Synonym—*Pernio.*

Chilblains are a localised effect of cold upon the extremities. They usually occur in young people with the so-called lymphatic constitution, in the anæmic, and very frequently in limbs affected by infantile paralysis; they appear to be associated with a deficiency of calcium salts in the blood. Capillary stasis takes place, followed

by thrombosis, exudation, and inflammation. Occasionally the blain bursts and a troublesome sore results.

Treatment.—By way of prevention, warm woollen clothes are to be worn and the wrists and ankles are to be specially protected. Boots lined with lamb's wool are very useful. The nutrition should be well maintained; cod-liver oil, the preparations of malt, iron, and the phosphates are useful. And above all, the salts of calcium, as shown by Sir A. Wright, act in many cases as a specific. Lactate of calcium, gr. v., or the following prescription:—Calcii Chloride, gr. x.-xv.; Ext. Glyc. Liq., ♏xx.; Aq. ad ℥j. given for from ten to twenty-one days at the commencement of cold weather prevents the blains forming in most people, and if they are present cure, at any rate for the winter, follows in about 70 per cent. Locally, free rubbing with stimulants and counter-irritants relieve the itching and pain. If the chilblain is broken it should be treated as an ulcer.

ERYTHROMELALGIA AND RAYNAUD'S DISEASE

Erythromelalgia is characterised by flushing and swelling of the feet and legs, or of the hands and forearms, accompanied by burning pain in the parts. The affection is often patchy, but later it becomes diffuse and assumes the appearance of Raynaud's disease. In women of a neurasthenic type this affection is particularly well marked. It appears to be a vasomotor disturbance.

In elderly people very severe pain, quite distinct from that found in flat foot, is sometimes met with, and if the anterior tibial arteries are examined they are found to be thickened and the pulsation considerably reduced. In such cases the author has found codeine, gr. $\frac{1}{8}$ three times a day, of great service.

INTERMITTENT LIMPING

Synonyms—*Dysbasia angio-sclerotica*; *Myasthenia angio-sclerotica*; *Intermittent claudication*; *Angina cruris*; *Claudication intermittente* (Charcot); *Intermittierendes Hinken.*

The disease is a disturbance of the arterial circulation, particularly of the legs, and often so severe as to cause gangrene. At its onset, the patient finds that while walking he is seized with pain in the calf of the leg, which causes him to limp, and then to stop and rest. After a time he is able to proceed, but a similar

train of symptoms follows. In these attacks the circulation of the lower extremities is slowed, and the pulse in the posterior tibial and dorsalis pedis arteries is diminished or disappears.

Lovett, who has written an exhaustive article on the subject,[1] says that, in the cases he has met with, the characteristic and striking symptoms were:—

1. Pain and cramp in the calf of the leg in walking.
2. Obstruction to the arterial circulation shown by pallor and coldness of the foot.
3. Absence of the pulse in the dorsalis pedis and posterior tibial arteries in two of his cases.
4. Pain on letting the foot hang down when the blood entered the arteries.
5. A feeling of coldness of the foot during the night.
6. Severe spontaneous pain during the night.
7. A tender induration of the calf of the leg.
8. Static flat foot.

There is no doubt that men are more often affected than women, 17 to 1, and the affection is unilateral or bilateral. In very rare instances the arms have been involved. Jews are especially liable to the disorder. As to the exact causation opinions differ. The excessive use of tobacco was given a prominent place by Erb, who found 55 per cent of excessive smokers in 43 cases. Other observers have cited extremes of heat and cold, syphilis, alcoholism, and diabetes; and Lovett invokes static trouble of the feet and pressure upon their arteries as causes.

Pathologically, the conditions usually associated are of two kinds, either sclerosis and the formation of calcareous plates, which may be demonstrated by X-ray pictures, or a proliferation of the intima and the media with general occlusion of the lumen. In one patient, a Jew, who came under my care, very severe obliterative arteritis came on in both legs, beginning with the usual train of symptoms, and it was succeeded by gangrene first in one leg and then in the other, so that amputation of both limbs through the lower third of the femur was necessary. Examination of the popliteal arteries just above the bifurcation showed that the lumen of the vessels was entirely blocked by organised fibrous material.[2]

Treatment is not very satisfactory. Absolute rest to the leg

[1] *Amer. Jour. Orth. Surg.*, 1906, vol. iv. No. 2, pp. 120-134.

[2] Cf. Report of a case by R. W. Lovett, *Trans. Am. Orth. Ass.* vol. iv. No. 2, p. 128. Also *Lancet*, 26th November 1910, pp. 1565, 1566.

is essential until opportunity has been given for the circulation to be restored. Massage, vibration, hot and cold douching, galvanism were all tried in my case and failed; while among drugs codeia, mercury, and potassium iodide failed too. In such cases some or all of these remedies should be tried, and are successful from time to time, for it is quite certain that cases differ in their ætiology and pathology in a way we are not fully cognisant of; and some have a tendency to recover under palliative treatment, while others steadily drift towards gangrene despite all efforts.

When gangrene is spreading, especially if, as often happens, the pain and suffering are extreme, then amputation should be performed, and experience shows that through the lower third of the femur and above the division of the popliteal artery is the best site.

Lovett gives a very comprehensive list of references, which is reproduced here, in a modified form, from his article referred to previously.

References

Auerbach. Deutsche Zeitschr. f. Nervenheilkunde, xi. 142.
Bergmann. Beitr. zur Kenntniss d. Angiosklerose. Dorpat, 1890.
Borchard. Deutsche Zeitschr. f. Chir., 1897, 44, 131.
Bourgeois. Thèse de Paris, 1897.
Brissaud. Rev. neurol., 1899, xiii.
Charcot. Comptes rend. et mém. de la Soc. de Biol. 2nd series, xii. 225.
Charcot. Prog. méd., 1887, 32 and 33.
Charcot. Bull. méd., 1891, Dec.
Dana. N.Y. Med. Rec., Feb. 22, 1902.
Dehio. Deutsche Zeitschr. f. Nervenhlkde, 1893, vi.
Dehio. Berl. kl. Wchsft, 1896, 37, 817.
Delaunay. Thèse de Paris, 1890.
Dutil and Lamy. Arch. de méd. exp. et d'anat. path., 1893, ii. 102.
Edgren. Kliniska studier öuer arterio-skleros. Stockholm, 1897.
Elzholz. Wien. med. Wochenschrift, 1892, 49 and 50.
Erb. Deutsche Zeitschr. f. Nervenhlkde, 1898, xiii. 1.
Erb. Münch. med. Wochenschrift, May 1904.
Gordon. N.Y. Med. Journal, 1900, Sept. 10, 806.
Goldflam. Deutsche med. Wochenschrift., 1895, 36.
Higier. Deutsche Zitschr. f. Nervenhlkde, 1901, xix.
Haga. Virch. Arch. 152, p. 26.
Heidenreich. Sem. méd., 1892.
Homén. Finska Däkalesällsk Handlingar, 1900.
Idelson. Deutsche Zeitschr. f. Nervenhlkde, xxiv. 1903.
Laveran. Sem. méd., 1894, 100.
Levet. Thèse de Paris, 1894.
Lapinsky. Deutsche Zeitschr. f. Nervenhlkde, 1898, xiii., and 1899, xv.
Lanceraux. Sem. méd., 1894.
Mitchell and Spiller. Am. Jour. Med. Sciences, 1899 cxvii. 1.

MARIENSCO. Sem. méd., 1896, No. 9.
MARGOLIN. Inaug. Diss., Freiberg, 1905.
MASSAUD. Neurol. Centralbl., 1901, 953.
MEHNERT. Über die topog. Verbreitung d. Angiosklerose, etc. Dorpat, 1898.
MUSKAT. Verhandl. d. deutsche Ges. f. orth. Clin. 5th Congress, p. 184.
NOTHNAGEL. Zeitschr. f. kl. Med., 1891, xix.
OORDT. Neurol. Centrlbl., 1900, 795.
OPPENHEIM. Deutsche Zeitschr. f. Nervenhlkde xvii., 1900.
PANAS. Sem. méd., 1894, 265.
PITRES and VAILLARD. Arch. de physiologie, 1885.
PUTNAM. Boston Med. and Surg. Journ., 1901, Feb. 21, 182.
RIESMAN. Am. Med., May 25, 1903, p. 343.
RIMEBERG. Die Ther. d. Gegenwart, 1900.
SCHLESINGER. Neurol. Centralbl., 1895, xiii. and xiv.
STERNBERG. Wien. klin. Wochenschrift, 1895, 37 and 39.
STRASSMANN. Deutsche Arch. f. kl. Med., 1899, 66.
SANGER. Neurol. Centralbl., 1901, 1067.
SCHRÖTTER. Nothnagel's Spec. Path. und Ther. Bd. v.
THOMA. Virch. Arch., 1886, 105.
THOMA. Deutsche Arch. f. klin. Med., 1888, xliii. 409.
WILL. Berlin. kl. Wochenschrift, 1886.
WEISS. Deutsche Zeitschr. f. Chir., 1895, xl. i.
WINIWARTER. Arch. f. klin. Chir. xxiii. 202.
WIREDENSKY. Langenbech's Archiv, 1898.
WALTON and PAUL. Boston, M. and S. Journal, Apr. 3, 1902.
ZOEGE MANTEUFFEL. Arch. f. klin. Chir., 1891, 42, 569.
ZOEGE MANTEUFFEL. Centralbl. f. Chir., 1902, No. 3.

GIGANTISM

Hypertrophy of one or more of the fingers and toes is seen. It affects in some cases all the tissues, in others the subcutaneous tissues only. The growth is sometimes of lymphatic origin, at others of fatty origin, and constitutes a hypertrophy known as diffuse lipoma, the characteristics of which have been adverted to in discussing the diagnosis of "acquired painful lipoma."

SECTION III

STATIC DEFORMITIES

CHAPTER I

SYMMETRY AND ASYMMETRY AND THEIR INFLUENCE UPON LATERAL CURVATURE OF THE SPINE

THE sides of the body are rarely symmetrical; they are more often unequal either in length or general development, and the effects of this asymmetry are far-reaching. We have described the inequality of the sides of the face in congenital torticollis, and referred to the view that it is due to retardation of the flow of blood through a partially compressed carotid artery. If we study the faces of people we observe that very few are symmetrical, and a slight lack of it often adds piquancy to the expression. How constant the difference of one side of the face from the other is may be seen in the busts of the Roman Emperors of the Julian line. In all, from Julius Caesar to Nero, the left eyebrow is a little lower than the right, and the left palpebral fissure smaller. So marked is the absence of symmetry that we read of a king of Sweden who was known as the "King with Two Faces," for the expression of the two sides of the face was entirely different.

In many instances asymmetry is of congenital origin and exists from birth, although it is frequently not noticed until some complaint of discomfort or fatigue is made by the patient, and then careful measurements are taken, and the difference is ascertained.

Hunt[1] of Philadelphia in 1879 found that symmetry of the lower limbs is quite exceptional. Cox[2] found that in only six of fifty-four people were the limbs of the same length; and Wight[3] states that only one person in five has limbs of equal length, the difference being from $\frac{1}{8}$ to 1 inch. Garson[4] measured seventy skeletons, and says the lower limbs were equal in only 10 per cent. So great is the asymmetry that limping may be seen when the

[1] *Amer. Journ. Med. Sci.*, Jan. 1879. [2] *Ibid.*, 1875.
[3] *Arch. Clin. Surg.* vol. i. No. 8, Feb. 1877.
[4] *St. Bart.'s Hosp. Rep.* vol. xiv., 1878, p. 187.

child begins to walk, as Burrell[1] reported in three cases; and Broca[2] describes a boy of eleven years who appeared "as if the two sides of the body were different-sized persons joined together." There is no uniformity as to which side of the body or which lower limb is the longer or larger; indeed, as we shall show, "crossed asymmetry" is not uncommon.

The *Ætiology* of asymmetry is in many instances obscure. In many instances it is—

1. *Congenital.*—From his observations, the author believes the effect of asymmetry in the parents to be as follows. If both parents are smaller, *e.g.*, on the left side than on the right side, then the offspring exhibit a simple asymmetry, all having the left side of the body, with the leg on that side, smaller than the other.

If, however, one parent is smaller on the left than on the right half of the body, and has the left leg smaller than the right; whilst the other parent is smaller on the opposite side, then a condition of crossed asymmetry obtains frequently in the offspring, *i.e.* the left half of the trunk is smaller than the right half, but the left leg is longer than the right; or the left half of the trunk may be longer than the right, and the left leg smaller than the right. The bearing of this upon scoliosis will be explained presently.

Other cases of congenital asymmetry are explicable by congenital hemiplegia. Then the irregular incidence of achondroplasia fœtalis will account for some cases of disparity in the halves of the body.

The inequality of the sides of the face in congenital torticollis increases with the deformity, and decreases, to disappear finally, after the contraction of the sterno-mastoid muscle is relieved. Hypertrophy of one limb is commonly seen in plexiform angioma, lymphangioma, gigantism, and other such affections.

2. *Acquired.*—Chief among them are nerve-lesions such as infantile paralysis, spastic hemiplegia, and possibly progressive facial hemiatrophy arising from a tropho-neurosis of nerve ganglia.

Then the coarser lesions, such as unilateral flat-foot, genu-valgum, coxa-valga and vara, and congenital dislocation of the hip cause asymmetry in the length of the lower extremities.

Symptoms.—One of the most frequent results of asymmetry of the legs is seen in weakly and anæmic women. They complain of general backache or lumbago, or have intense and persistent

[1] *Boston Med. and Surg. Journ.* vol. cvi. p. 462.
[2] Canstatt's *Jahresbericht*, 1859, vol. iv. p. 6.

pain over one sacro-iliac joint,[1] which is relieved by rest, and by compensating the shortness of one leg by a cork sole in the boot. Another symptom is persistent pain referred to the sciatic nerve. Such a case came to the notice of the author. A rancher from Patagonia had sought relief for over three years from what was diagnosed as sciatica, and feared he would lose his occupation. A measurement of the lower limbs revealed the fact that the left or

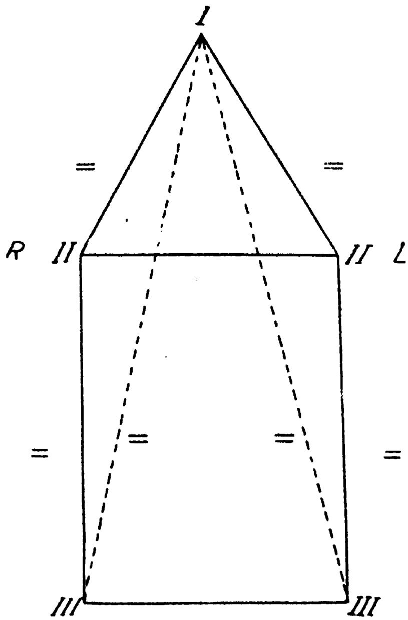

FIG. 282.—To demonstrate Method of Measurements for Symmetry and Asymmetry. R, Right; L, Left; I. Centre of Sternal Notch; II. Anterior Superior Spines; III. Internal Malleoli. =, Sign of Equality of Length of Measurements.

painful leg was one inch shorter than the right. Correction was made by a cork sole in the left boot, and in three weeks all the pain had gone. Children who are asymmetrical frequently complain of backache, growing pains, and painful hip, even to such a degree as to simulate coxitis.

From a static point of view the effects of asymmetry on the spine in the production of scoliosis must be reckoned with, and in

[1] In this connection a valuable article on "Further Studies of the Relaxation of the Sacro-iliac Synchondrosis," by Dr. John Dunlop, *Amer. Journ. Orth. Surg.* vol. v. No. 1, July 1907, p. 151, should be studied.

every case careful measurements ought to be taken. In 80 per cent of scoliotic patients the author finds asymmetry present, and it is of two kinds, simple and crossed.

Before we describe them, we indicate the method of measurement. The tape is carried from I. to III. directly on each side,[1] the patient being recumbent, and any difference in length noted. In this way we obtain an idea as to the presence or absence of

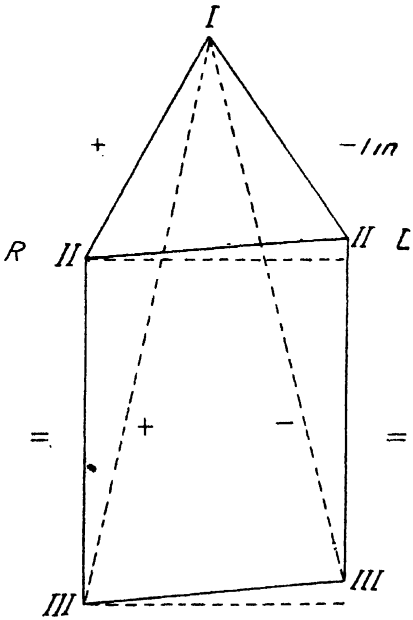

FIG. 283.—Simple Asymmetry. The left half of the trunk is smaller than the right, but the legs are equal. Correction required on the left side in standing and sitting.

symmetry. It is required to ascertain in which parts it is present, if it is in the trunk or legs, or both or neither. Therefore we measure from the middle of the sternal notch I. to the anterior superior spines II., and from the latter to the internal malleoli III., and compare R I. to II. with L I. to II., and R II. to III. with L II. to III.

[1] The figures are drawn as if the patient were facing the observer, hence the position of R and L; but to see the effect of the corrections on the spine the observer must sit or stand behind the patient, and then the figures must be reversed. The latter are highly diagrammatic. They do not pretend to have any accuracy as to the proportional measurement of the trunk, width of the pelvis, and length of the legs. They are merely inserted to illustrate the text.

Simple Asymmetry may exist in three ways:—

(*a*) In the trunk (Fig. 283), R I. to III. > L I. to III., but it is found that R I. to II. > L I. to II., and R II. to III. = L II. to III., *i.e.* it is the left side of the trunk, which alone is small. Correction by a cork sole is required beneath the left foot in standing, and a pad beneath the left tuber ischii in sitting, in order to overcome the obliquity of the pelvis and deviation of the spine in these positions.

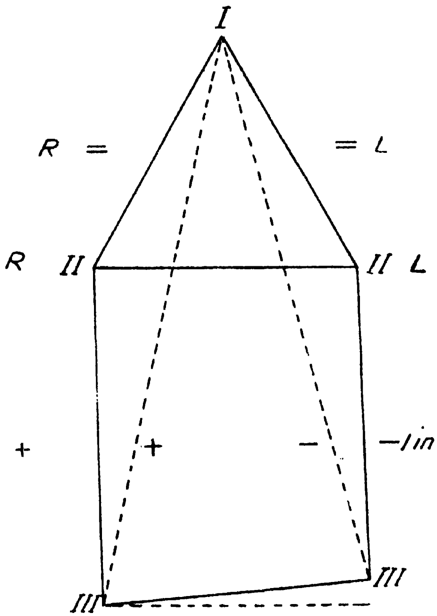

FIG. 284.—Simple Asymmetry. The halves of the trunk are equal, but the left leg is shorter than the right. Correction required on the left side in standing only.

As a rule the lumbar spine deviates to that side of the pelvis which drops.

(*b*) In Fig. 284 the trunk is equal on the two sides, but the left leg is shorter than the right, *i.e.* R I. to III. > L I. to III., and R I. to II. = L I. to II., but R II. to III. > L II. to III. In standing, the pelvis drops to the left, but not in sitting. Therefore a cork sole is required beneath the left foot in standing only, and no correction is required for sitting.

(*c*) R I. to III. > L I. to III. (Fig. 285), but the difference is divided in varying degrees between the trunk and pelvis, *i.e.* R I.

to II. > L I. to II. and R II. to III. > L II. to III. The pelvis drops to the left, and correction is required beneath both the left foot in standing and the left side in sitting.

The best way of correcting in sitting is to have a horsehair pad of $3\frac{1}{2}$ to 4 inches square, and about $\frac{1}{4}$ inch thicker than is required, so as to allow for compression. In females it is attached to the "combinations," and in males to the pants, by a pin or a tab

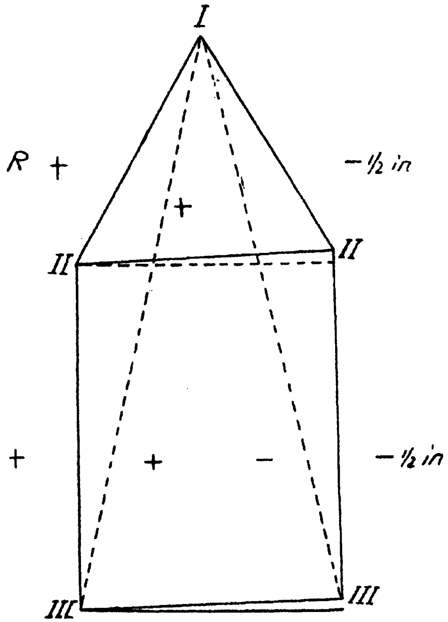

FIG. 285.—Simple Asymmetry. The left side of the trunk is smaller than the right, and the left leg is shorter than the right. Correction required beneath the left side in both standing and sitting.

and button, so that when the individual sits, the pad comes beneath the tuber ischii. These then are the varieties of simple asymmetry. We now pass on to

Crossed Asymmetry.—This is of two kinds—

A. Non-Compensated, by lengthening elsewhere.

B. Compensated, by lengthening elsewhere.

A. Non-Compensated.—1. Difference more marked in trunk. Here (Fig. 286) the measurement from the sternal notch to the internal malleolus is greater on the right side than on the left, *i.e.*

R I. to III. > L I. to III. And it is found that the right side of the trunk is greater than the left, *i.e.* R I. to II. > L I. to II. But the right side of the pelvis and leg are shorter than the left, *i.e.* R II. to III. < L II. to III.; yet the greater length of the left leg as compared with the right does not compensate for the greater length of the trunk on the right side, and the left side of the individual is as a whole shorter than the right. The pelvis drops to the left

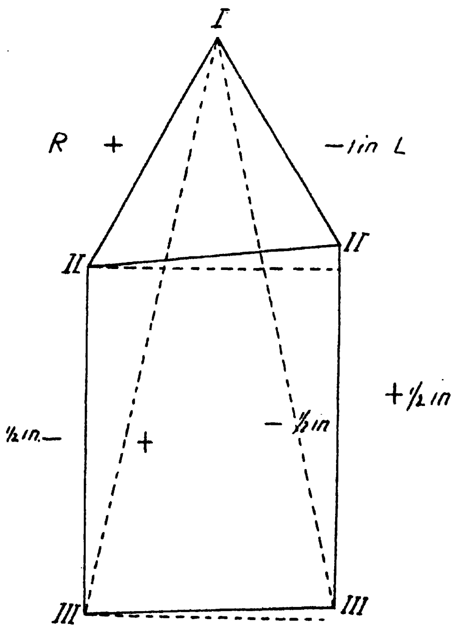

FIG. 286.—Crossed Asymmetry, non-compensated. R I. to III. > L I. to III. The right side of the trunk is larger than the left, but the right leg is shorter than the left, and the compensation is not complete, *i.e.* R I. to III. is greater than L I. to III. Correction required beneath left side both in standing and sitting.

both in standing and sitting. Therefore correction must be made beneath the left foot in standing and the left side in sitting.

2. Difference more marked in leg (Fig. 287). The measurement from the sternal notch to the internal malleolus is greater on the right side than the left, *i.e.* R I. to III. > L I. to III. And it is found that the right side of the trunk is smaller than the left, *i.e.* R I. to II. < L I. to II., but the right side of the pelvis and leg is so much longer than the left, *i.e.* R II. to III. > L II. to III., that the shortening of the left leg fails to compensate the shortening

of the right side of the trunk, and the left side of the individual is shorter as a whole than the right side, and R I. to III. still is greater than L I. to III.

The pelvis drops to the left side in standing and to the right side in sitting. Correction therefore is made beneath the right side in sitting and the left side in standing.

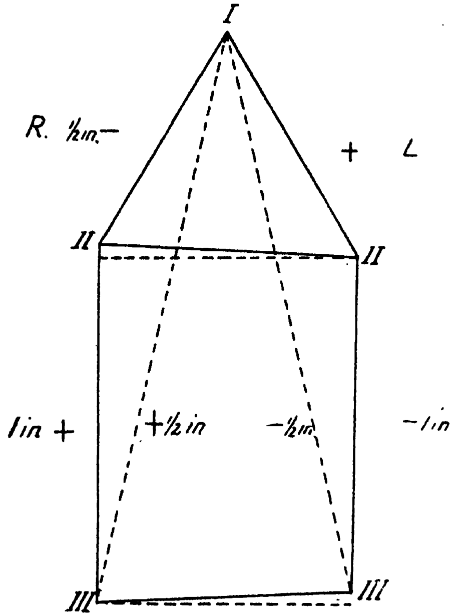

FIG. 287.—Crossed Asymmetry, Non-Compensated. R I. to III. > L I. to III. The right side of the trunk is smaller than the left, and the right leg is longer than the left, but the compensation is not complete. Correction is made beneath the right side in sitting, and the left side in standing, *i.e.* in standing R I. to III. is greater than L I. to III.

B. Compensated.—1. The measurements from the sternal notch to the internal malleoli are equal on the two sides (Fig. 288), *i.e.* R. I. to III. = L I. to III. But, on analysis, the distance from the sternal notch to the anterior superior spine is greater on the right side than the left, while the distance from the anterior superior spine to the malleolus on the right side is so much less as compared with the left, that it is sufficient to compensate for the difference between the two sides of the trunk, *i.e.* R I. to II. > L I. to II., but R II. to III. < L II. to III., and the differences are so equally arranged

on either side of the patient that the total measurement from the sternal notch downward is equal on the two sides, and R I. to III. = L I. to III. In this case correction is called for beneath the left side in sitting. Very rarely is it necessary to have a thickening beneath the right side in standing, unless the difference between the legs is extreme, because the patient instinctively bends

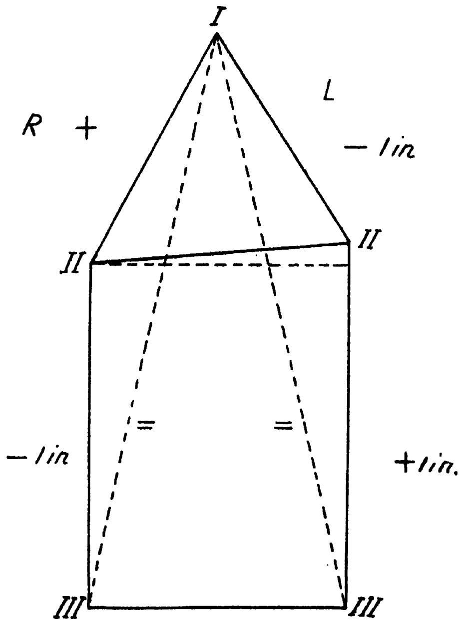

FIG. 288.—Crossed Asymmetry, Compensated. R I. to III. = L I. to III. but R I. to II. > L I. to II., and R II. to III. < L II. to III. Correction required beneath the left side in sitting. It may be advisable in extreme cases to correct beneath the right side in standing.

the left knee a little, so as to keep the pelvis level and the spine erect in standing.

2. Here again (Fig. 289) R I. to III. = L I. to III., *i.e.* the two sides of the patient are equal in length, but the right half of the body is smaller than the left, *i.e.* R I. to II. < L I. to II., while the right side of the pelvis and leg is longer than the left, *i.e.* R II. to III. > L II. to III., and is just in sufficient proportion to correct the difference between the sides of the trunk, *i.e.* R I. to II. + R II. to III. = L I. to II. + L II. to III. or R I. to III. = L I. to III.

Correction is required beneath the right side in sitting, but not

beneath the left foot in standing, unless the pelvis drops very much to the left, for the patient readily compensates the longer right leg by bending the knee, so as to preserve his equilibrium in standing, and keeps the pelvis level, and the spine erect.

These curious conditions of crossed asymmetry are met with in a proportion of 1 in 4 of all cases of asymmetry, and much more frequently in Jews than others. In fact, in two of the author's

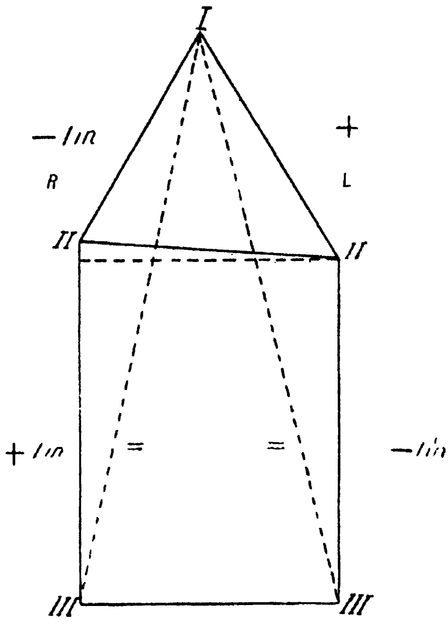

FIG. 289.—Crossed Asymmetry, Compensated. R I. to III. = L I. to III., but R I. to II. < L I. to II., and R II. to III. > L II. to III. Correction required beneath the right side in sitting, and in extreme asymmetry beneath the left side in standing.

patients, as they walk, a curious spasmodic movement of adjustment in the middle of the back can be observed with every step forward, and the upper part of the trunk sways first to the right and then to the left. This is an acquired way of maintaining the equilibrium and balance in the upright position. In other cases a definite lateral deviation and curvature develop, and the spine often becomes amesial, and therefore overhangs the mid-line to one side or the other.

These observations explain why the spine sometimes deviates to the side of the longer leg when the patient is sitting instead

of to the shorter leg, and why corrections may be required on one side in sitting and the opposite in standing. They also explain why the curvature of the spine is sometimes on the side of the apparently shorter leg, and sometimes on that of the seemingly longer leg, and why it is sometimes on one side in sitting and the reverse in standing. Therefore the author has been at pains to analyse his cases of lateral curvature by the measurements as given above, and the results throw light upon some difficult points in the ætiology of scoliosis.

CHAPTER II

SOME POINTS IN THE PHYSIOLOGY OF THE SPINAL COLUMN

The Spinal Curves—Normal Attitude—Spinal Movements—The Effects of Age upon the Spine—Influence of Occupation—Causation of Spinal Curvature—Maintenance of the Upright Position, Equilibrium, and Balance.

THE vertebral column consists of two parts, the anterior or the column of the bodies, essentially supporting in function; and the posterior or column of the arches, which forms a protection for the medullary substance, a means of attachment for the spinal muscles and ligaments, and is secondarily concerned in support. The importance of this distinction will appear in discussing scoliosis and Pott's disease.

The spinal column, including the sacrum and coccyx, forms about $\frac{4}{10}$ of the total stature in the adult. The distance from the odontoid process to the end of the sacrum is on an average 28 in. in the male, and 27 in. in the female; but there is very considerable variation in individuals. If the spinal column is measured along its curves the length is one to two inches more.

The spine is not straight. It presents four curves in the median or sagittal plane (Fig. 290). Two are convex backward, the sacral and dorsal kyphoses; and two are convex forward, the cervical and lumbar lordoses. The latter should be more accurately described as cervico-dorsal and lumbo-sacral lordoses. In the erect posture the line of gravity is said by Lovett[1] to pass through the bodies of the 2nd and 12th dorsal vertebrae, and to touch the lower border of the anterior part of the last lumbar vertebra. According to Staffel, the line cuts the lumbar lordosis anteriorly, and lies in front of the spine above this. We must bear in mind, however, that the normal attitude is conventional, and varies according to different observers. This will be clear when we discuss the question of kyphosis and round shoulders.

[1] *Lateral Curvature of the Spine and Round Shoulders*, p. 3.

The physiological antero-posterior curves vary with age, race, individual, state of muscularity, adiposity, and nature of calling. The curves are hereditary, but subject to modification. During intra-uterine life a general kyphosis, but showing quite early signs of the sacral promontory, is present. At birth the column above the sacrum is almost straight, except that there are indications of commencing cervico-dorsal lordosis. The post-natal development of the normal physiological curves is a phylogenetic (hereditary) process fundamentally. To appreciate this point care must be taken not to confuse the terms "congenital" and "heredity." The development of the lumbar and cervical lordoses is due to the formation of compensatory curves, in order to neutralise the primitive general kyphosis, an indispensable change in the assumption of the erect posture. In this alteration muscular action plays the chief part, the intervertebral discs being passively modified, and to a less extent the bones. Anatomically, it may be stated that the kyphotic curves arise from the shape of the bones, whilst the lordotic depend on the shape of the discs. This is well shown by Fig. 291.[1]

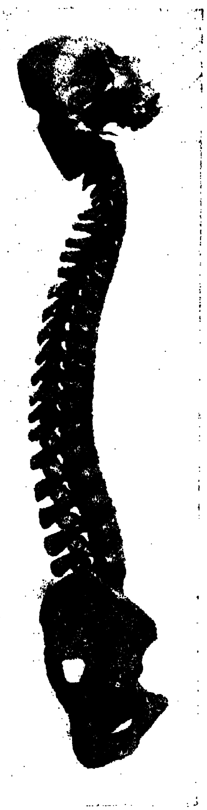

FIG. 290.—Lateral view of the Spinal Column, showing the Physiological Curves (R. W. Lovett).

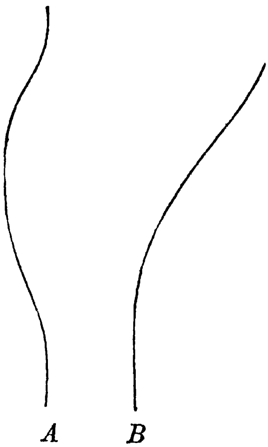

FIG. 291.—Curves of the Vertebral Column (Fick). A, with Intervertebral Discs; B, without Intervertebral Discs.

It follows that the individual discs—of which there are 23—are not of uniform thickness throughout, but where lordosis exists they are wedge-shaped, thicker in front than behind. This is especially marked in the disc between the last lumbar and first

[1] Lovett, *Lateral Curvature of the Spine and Round Shoulders*, p. 5.

FIG. 292.—Lines representing the sum of the Thickness of the Intervertebral Discs (Fick). v, at the front borders of the discs; m, in the middle; h, at the posterior Borders.

sacral vertebra. The discs as a whole form about $\frac{1}{4}$ of the height of the spinal column. The sum of the heights of the discs is greatest through their centres, then along their fronts, and least along their posterior aspects (Fig. 292). The discs are very firmly attached to the vertebræ, and being elastic and compressible form synarthrodial joints permitting movement in any and every direction, within the limits of their elasticity and the restrictions imposed by the configuration of the bones. Where the proportion of disc to bone is greatest, as in the cervical and lumbar regions, movement is most free. Where the discs are proportionately smaller, as in the dorsal region, movement is restricted.

The *movements* of the spinal column take place in all directions, but they are more limited than is usually supposed, especially rotation and lateral flexion. The observer is misled and attributes to the spine movements actually taking place in the occipito-atloid and hip joints, and shoulder girdle. Further, it must be admitted that there is at present considerable disagreement between authorities owing to the diverse conditions of the experiments. It must not be assumed that the behaviour of an isolated spinal column sawn through in the mesial sagittal plane (Ménard, Guibal) is the same as that of the spine in the intact living body. Thus, in the living subject, hyper-extension is limited by the tension of the anterior body wall, and flexion of the cervical spine by the tension of the ligamentum nuchæ and other posterior structures. Lovett's experiments and methods are the most valuable, because he compares the behaviour of the isolated spine with that of the cadaver and living model. But Lovett's contention that the column, composed of bodies and discs alone, behaves the same as an intact spinal column is open to argument.

The movements of the spine are flexion, extension, and hyper-extension in the sagittal plane;

in the frontal plane, lateral flexion or side bending; about the long axis, rotation or torsion. Rotation and side bending are interdependent, and neither exists as an isolated movement.

Movement in the sagittal plane is the simplest of all, as it is unaccompanied by rotation. Its exact range is difficult to decide. Meyer and Horner found that in the cadaver, in passing from the limit of flexion to that of hyper-extension, an arc of 64° is described. But, if the cervical region is included it is evidently much more, for the neck alone can be so hyper-extended in the intact cadaver that the odontoid process becomes horizontal.[1] Lovett finds that the cervical region cannot be accurately observed nor measured in the model, and that no conclusions can be drawn beyond the statement that its forward convexity may be obliterated by forcible flexion with the hands.[2] We may take it that in the skeleton, stripped of its soft parts, but leaving the spinal ligaments, flexion and extension in the cervical region are very free, extension or hyper-extension being more so than flexion. In the living subject these movements are limited by the extra-spinal parts, so that the exact range of movement of the spine in this region, when flexion is thus restricted, has not been determined. Flexion of the spine as a whole is more evenly distributed than other movements. The lumbar region takes the chief part in flexion, but it is probable that the lumbar lordosis, although straightened out, never becomes replaced by kyphosis. The dorsal region becomes decidedly more kyphotic in flexion, especially in its upper portion, the mid-dorsal is least affected, and the two lowest dorsal vertebræ behave as lumbar.

In hyper-extension the dorsal region takes little part, the dorsal kyphosis being flattened out a little, but not disappearing. The movement is performed in the lumbar region, the 11th and 12th dorsal vertebræ acting with the lumbar vertebræ, so that there is an increase of the lumbar lordosis.

Lateral flexion in a pure form, unaccompanied by torsion, we have already said, does not exist. If the spinal column were a straight, cylindrical staff, pure lateral flexion might be obtained; but it is not. If looked at sideways the outline of the spine is in no way symmetrical, and even if we disregard the arches altogether and consider the isolated column composed of the bodies and discs only, the irregularity persists, owing to the physiological curves. Now a straight elastic rod can be bent in any plane without

[1] Ménard, *Étude pratique sur le mal de Pott*, fig. 32, p. 42.
[2] Lovett, *Lat. Curvature*, p. 24.

undergoing torsion, but a rod curved in one plane cannot be bent in another without torsion being set up. The spine being curved in the antero-posterior plane, then on lateral deflection torsion or rotation results. Thus if a subject is made to bend forward, the ribs are seen to be on a level. If a bend to the right is now superadded the ribs no longer remain level, but the left rise, showing that the bodies of the dorsal vertebræ have rotated to the convex side of the lateral curve. About this there is no manner of doubt. We now come to certain points that cannot be at present disposed of dogmatically. As we have seen, the antero-posterior curves are modified in flexion and extension, and we should expect the character of the rotation to be modified according as lateral flexion is induced in the upright or in the stooping position. And this is so, although as to details observers are not agreed. Very briefly put, Lovett finds that:—

"Side bending in the erect position is most marked below the 10th dorsal vertebra, the dorsal region taking a very small share in the movement, and is accompanied by rotation of the bodies to the concave side of the curve. This applies also to side bending in the hyper-extended position, in which position the dorsal region is locked against lateral movement."

"Side bending in the flexed position is a dorsal movement, the lumbar region being comparatively locked, and it is accompanied by convex-sided rotation."

If we put these statements in other words, lateral flexion of lordotic segments is accompanied by concave torsion; that of kyphotic segments by convex torsion.

Lovett's conclusions have been exhaustively criticised by Lorenz,[1] who is unable to accept concave rotation of lordotic segments, but finds "always and everywhere only convex rotation associated with side bending." Lovett's methods have also been adversely criticised by Reiner and Werndorff,[2] whose experiments failed entirely to produce concave torsion. In discussing the subject it is often very difficult to interpret photographs correctly, whereas it is relatively easy for an observer to convince himself by direct observation on a suitable model. The author has been unable to find any definite signs of concave rotation on side bending in the erect posture, as evidenced by fulness and resistance in the lumbar region on the side to which the subject bends. He is therefore inclined to agree with Lorenz.

[1] *Zeitschr. f. orthop. Chir.* xix. pp. 172-191. [2] *Ibid.* xiv. 1905.

Rotation or twisting of the spine on its long axis is a movement proper to the cervical and dorsal regions in the erect spine, and in hyper-extension to the dorso-lumbar region. It is accompanied by lateral deviation, convex on the side opposite to which rotation occurs. Thus rotation forward to the right is accompanied by a lateral curve convex to the left. That is to say, in this case concave rotation exists on the right side. If the right shoulder is rotated backward, then the lateral deviation is to the same side, and a lateral curve convex to the right appears. In this case convex rotation is to the right side. A slight normal curve to the right side has been said by some to exist, and undoubtedly a certain amount of asymmetry of the bodies of the vertebræ in contact with the aorta is often present. At all events, if the presence of the aorta is not indicated by a slight depression of the bones it will be found that the intervertebral discs show some traces. But whether anything more than this slight asymmetry is a normal condition is problematical. At all events, Sappey, Cruveilhier, Little, Adams, Bichat, and Béclard were unable to find it.

Effects of Age upon the Spine.—Osseous tissue is compressible, or rather bones are capable of, and do undergo, alterations of form and structure in response to altered static and mechanical conditions; and such changes are well exemplified in scoliosis.

The elasticity of the intervertebral discs is said by Fessler to be perfect, in that after compression for a short time they completely resume their normal shape. And they, like the bones, as will be seen later, undergo great and permanent changes in shape.

In early life the spine is largely cartilaginous, and correspondingly flexible. As age advances, the flexibility becomes less. In old age the rigidity present is in a measure due to the shrinkage and partial ossification of the intervertebral discs.[1] In advanced life thinning of both the cortical and spongy substance takes place, and sometimes at places complete absorption of the latter. Histologically, this is expressed as atrophy of the osseous elements, and may be called "osteoporosis senilis." In effect, the whole spine settles down, the individual bodies becoming more compressed or wedge-shaped in front, with resulting increase of kyphosis; yet occasionally, in the lumbar region, the compression and absorption

[1] This, with ossification of the ligaments, especially the anterior common ligament, may lead to the vertebral bodies becoming connected by a bridge of bone, covering up the remains of the disc. Schulthess figures such a case in a woman aged 79 years (Joachimstal's *Handb. f. orth. Chir.* Lief. iii. fig. 386).

changes of senility may be in the direction of increase of the normal lordosis. That is, the bodies become thinner posteriorly.[1]

The Influence of Occupation upon the Spine.—It is important to note that in fœtal life traces of the cervical lordosis and sacral promontory encroach on the general anterior concavity of the spine, and that at birth flattening also of the lumbar segment is seen. This shows that the ultimate formation of the spine is hereditary. But in a given individual there is no doubt that the nature of his occupation impresses on the spinal column certain distinctive acquired changes in shape, as in cobblers, coal-heavers, and masons' labourers. The influence of function on the production of deformity, then, must be constantly borne in mind. This factor was possibly over-estimated by J. Wolff. The enunciation of his law has passed through the phases of enthusiasm, over-valuation, too wide generalisation, and is now being subjected to destructive criticism. Its true value will be apparent in due time. Too much attention has been directed to the influence of loading, and insufficient stress laid on tension due to muscular contraction—a tension necessary in order to balance and support the load. It must be admitted that this tension is a difficult matter to estimate, and is a point concerning which no sort of agreement exists. Possibly it may explain some cases of scoliosis in quadrupeds and fishes,[2] although doubtless the bulk of the cases in animals are due to an asymmetrical growth of bone.

We may say, then, that the first cause of the form of the normal spine is heredity, and that the effect of function is not yet distinctly understood; and it is difficult to say how far the differences between the infantile and adult spine are purely functional in character.

In the production of spinal curvature Schulthess[3] lays stress on the following factors:—

1. The resisting powers of the vertebral column, its shape, elasticity, firmness, and tension.
2. The body weight and alterations in its centre of gravity.
3. Muscular tension and its variations.
4. Additional loading.

And of these he regards the first and third as especially important. The conditions resulting from the action of these factors is expressed by—

[1] Joachimstal, figs. 388, 389.

[2] The author possesses a specimen of very marked scoliosis taken from a sole.

[3] Joachimstal, *op. cit.* p. 556.

(*a*) Alterations in form due to mechanical influences; alterations which are capable of being elucidated by experiments on non-living material, such as elastic rods; and

(*b*) Secondary alterations in the nature of the reaction of the body to the primary disturbance of form, as illustrated by departures from normal growth. These we shall deal with fully under pathological anatomy.

It is quite true that the primary changes in the bulk of the cases of deformity of the spine are of a more or less purely mechanical nature. If the deforming factors or forces act symmetrically, a kyphotic or lordotic change results; while if they act asymmetrically, the deformity is scoliotic. The asymmetrical spinal deformity may be due to a structural asymmetry elsewhere—for example, in the limbs or pelvis; but more often the asymmetrical factor is a functional one—for example, the excessive use of one arm. Again, unilateral movements associated with certain occupations, infantile paralysis affecting one side only, and faulty attitudes, are cases in point.

The Maintenance of the Upright Position.—This obviously depends on active muscular contraction. Relax the muscles as in syncope, sleep, anaesthesia, and so on, and the subject collapses. But it must not be at once crudely inferred that failure to maintain the erect position in scoliosis indicates inefficient muscular action. That may or may not be so, and we shall discuss it elsewhere; the point to be considered here is that the muscular action involved in the erect posture is of a highly complex nature. If one tries to hold, say, a light dumb-bell at arm's length for several consecutive minutes, the strain of the sustained muscular effort becomes unbearable. Hold the same bell erect over one's head, that is, *balance* it, and the effort is infinitely less. It is the same with the spine. The spinal muscles could not possibly *hold* it up for any length of time. They are assisted in maintaining the upright position by the anatomical construction of the spine, by the ligaments, and by balance.

But before discussing "balance" let us consider: What is the erect position? There is no one definite erect position. An obese person carries himself very differently from a thin one. The lumbar lordosis is increased during pregnancy. The spinal curves of a well-set-up soldier differ from those of the average civilian. In the average erect position the line of gravity falls through the knee and ankle joints and behind the hip-joints.

In this particular case the spinal extensor muscles keep the spine erect, and bearing in mind the relation of the line of gravity to the hip-joints, it is clear that if such muscles as the ilio-psoas and rectus abdominis were not in action the trunk would topple over backwards. That is to say, the body flexors are just as important in holding the spine erect as the extensors. Yet the shape of the trunk and spine varies constantly. If the subject *tries* to keep perfectly still, the line of gravity will be displaced with each respiratory act. Each slight extension of the spine in inspiration will call for a readjustment of all the muscles involved; and the active contraction of one set must be accompanied by the active relaxation of their antagonists. Space will not permit more than such brief hints, and they may be sufficient to suggest what an elaborate and complex process the co-ordination called for in balance is. Consider, for example, what takes place in passing from extension to hyper-extension, that is, in bending backwards. Schulthess points out that as soon as the trunk is bent so far back that the centre of gravity falls behind the sacrum, there is no need for the spinal extensors to contract further; the body weight does the rest. And the letting down of the trunk is further controlled by active contraction of the flexors of the trunk.

Balance, then, is the continuous adjustment by means of co-ordination of muscular action to the ever-varying position of the centre of gravity. And it is essential to grasp the idea, not of prolonged and wearisome muscular effort, but of constantly changing ripples of muscular action, no one set ever being contracted long enough to become fatigued.

So far we have been discussing "balance" whilst looking at the patient from a lateral position; in balancing, however, one has to consider not only antero-posterior but lateral spinal curves. A normal patient, looked at from the front or back, standing with the limbs symmetrical, presents a vertical median spine, and the line of gravity corresponds with the median line. But every asymmetrical movement calls forth a compensatory lateral deviation of the spine in order to keep the line of gravity within the supporting base. Thus if a weight is held in one hand, say the right, the pelvis immediately moves over to the left, the spine being curved accordingly. Again, in standing on one leg, the spine is curved so that the axis of the weight-bearing leg and that of the spine tend to become temporarily one. In fact, as Lovett points out, "every step, every raising of the arm, every tilting of the head, is accom-

panied by a deviation of the spine from the median plane of the body"—in other words, by a temporary lateral curve, which disappears when the symmetrical attitude is resumed.

In sitting, the body weight is supported by the ischial tuberosities and the under-surface of the thighs. If the pelvis is tilted back sufficiently, that is, if the "pelvic inclination" is diminished far enough, the coccyx and lower part of the sacrum afford further points of support.[1] Now, a lessening of the angle of pelvic inclination means that the upper surface of the first piece of the sacrum becomes more horizontal; that is, the base on which the spine rests is altered. This is compensated by a flattening out (p. 397) of the lumbar lordosis; that is to say, the spine becomes kyphotic. And sitting is of two kinds, sitting erect and relaxed. In the former, by muscular effort the spine is extended and the lumbar lordosis maintained. This is not a position of rest, unless the chair back is so arranged that mechanical support in the upper lumbar region replaces muscular tension. Sitting relaxed is the more important in its effect on the spine. The pelvis is tilted backwards to a maximal extent (the angle of inclination is diminished), and the spine is allowed to bend until further flexion is prevented by posterior ligamentous tension, or more often by the support afforded by the subject's arms resting on some object. The spine presents a general kyphotic curve, with its summit in the upper lumbar region. There is little or no attempt to compensate by muscular balancing for any anatomical anomaly present; and the centre of gravity being displaced forward, the weight is transmitted through the fronts of the vertebral bodies, a mechanical condition, as we shall show, very favourable for intensifying any tendency to lateral deviation. Frequently, too, the occupation is one involving functional asymmetry. Hence, sitting badly is a pregnant cause of scoliosis.

[1] The inclination of the pelvis is measured by the angle which a line, joining the upper border of the first piece of the sacrum and the top of the symphysis pubis, makes with the horizontal. This, in standing erect, is from 50° to 60°.

CHAPTER III

SCOLIOSIS OR LATERAL CURVATURE OF THE SPINE

General Considerations, Frequency, Sex, Age, Heredity—Clinical Aspects of Scoliosis—Morbid Anatomy and Pathology—Convex and Concave-sided Rotation—Changes in other Parts of the Body due to Scoliosis.

Synonyms—English, *Rotary Lateral Curvature*; French, *Scoliose, Déviation latérale de la taille*; German, *Skoliose, Seitliche Rückgratsverkrümmung, Kyphoskoliose, Bogenförmige Deformität der Wirbelsäule, Skoliose.*

Definition.—Scoliosis is a permanent deviation, laterally, of the spinal column, or a portion of it, so that the median line of the column composed of the vertebral bodies fails to coincide with the mesial sagittal plane of the trunk.[1]

General Considerations

Frequency.—My friend and colleague, Mr. F. R. Fisher, states that of 3000 cases which presented themselves for treatment at the National Orthopædic Hospital, 353 were affected by scoliosis.

Drachmann examined 28,125 children in the public schools of Denmark, and found 368 to be scoliotic. Whitman states that in hospital practice[2] it is, next to bow-legs, the most frequent deformity. In Switzerland the percentage of children with lateral curvature is found as high as 24·6 per cent. The value of such figures, however, depends on the standard adopted by the individual observer.

The occurrence of scoliosis varies much in different places. It is particularly great in large towns. In 3000 orthopædic

[1] The frontal plane is a vertical and transverse one; the sagittal or antero-posterior plane is a vertical mesial plane from before backwards. The term horizontal plane is sufficiently expressive.

[2] *Orthopedic Surgery*, 1904, p. 162.

cases Berend found 900 scoliotics. Langgard noted 700 and Schilling 600 in 1000 orthopædic cases seen in Clinics in different cities. Of 5079 consecutive cases seen by the author at the National Orthopædic Hospital, London, 428 were scoliotic.

Sex.—All clinicians admit that the deformity is more prevalent in girls than in boys, the proportion being about four or five to one. Rédard [1] says that in children under five years of age the proportion is equal in the two sexes, or perhaps is slightly greater in boys, and from the age of puberty the frequency of occurrence in girls as compared with boys increases very rapidly.

Age.—Scoliosis is a deformity of adolescence. Eulenburg found 78 cases from birth to the sixth year, 216 between the sixth and seventh years, 564 between the seventh and tenth years, 107 between the tenth and fourteenth years; and in 35 cases the distortion appeared after the last-named year. So that 57 per cent began between the ages of seven and fourteen. In 1023 cases Kirmisson records as follows:—In the four quinquennia from birth to twenty years the numbers affected were 62, 223, 569, and 159. Of these eleven were seen when under one year of age. Beyond the twentieth year ten cases were observed.

Heredity.—The hereditary character of some forms, at all events, is generally acknowledged, and the late William Adams had no doubts on this point.[2] Vogt [3] goes so far as to say that at least half the cases are of this nature. Eulenburg places the hereditary factor at 25 per cent, and Karewski at 12 per cent.

In this connection congenital scoliosis should be mentioned. It is a subject, however, which is more conveniently discussed under ætiological varieties.

The psychical factors concerned in the production and maintenance of scoliosis, together with the influence of bad postural conditions, will also be discussed under appropriate headings. And in this connection the remarks on the "Physiology of the Spine," sect. iii. chap. ii., should be read.

Clinical Aspects of Scoliosis

In a former edition of this work the author described and differentiated from scoliosis a pure lateral deviation, in the belief

[1] *Chirurgie orthopédique*, p. 283.

[2] Tubby, *Deformities*, 1st edition, p. 104, where accounts are given of four cases in the author's practice.

[3] Quoted by Rédard, *op. cit.* p. 284.

that a lateral bending of the spine can exist without rotation. In the light of recent researches by Lovett and others it is clear that lateral deviation must always be accompanied by rotation or torsion.

In modern nomenclature scoliosis is described as—

(*a*) *Functional*[1] *or Postural*—where the changes in the structure of the spine have not advanced so far as to prevent active or passive correction. This includes the bulk of the so-called "total" cases or single curves.

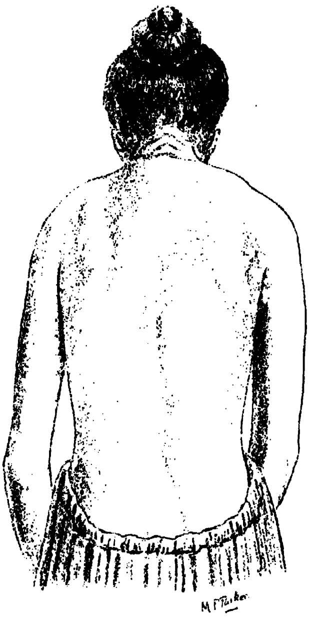

FIG. 293.—C-shaped Scoliotic Curve (Total Scoliosis), occupying the dorsal and dorso-lumbar regions, with general kyphosis.

(*b*) *Structural or Organic*—where definite changes have occurred in the shape of the vertebral and intervertebral discs, and in the ribs, shoulder-girdle, and pelvis.

As we shall see, the distinction, although from the point of view of prognosis useful, must not be pushed too far. So long as a single curve is not "fixed," it may be regarded as postural; but a definitely fixed curve, whether simple or not, indicates structural change.

Many curvatures commence as—

1. A long C-shaped curve to the left. These are examples of "total" curvature, the convexity being limited to one side only They often develop into—

2. The well-known S-shaped curve. The curves are named according to the side to which the convexity points, and the part of the spine affected. Thus, for example, a long C-shaped curve with the convexity to the left, if it embraces the whole length of the spine, is called left total curvature. When two curves are present, one with the convexity to the right in the dorsal region, and the other with the convexity to the left in the lumbar region, the scoliosis is called right dorsal and left lumbar (Fig. 294).

In describing a curve, it has been suggested that the tips of

[1] "Functional" is not used here in the sense expressed by J. Wolff, *e.g.* adaptive occupational curves; but merely as indicating an absence of marked structural change.

the spinous processes should be marked out, and the "seventh cervical and last lumbar spine" connected by a string.[1] This is not reliable, since the seventh cervical itself may be out of place. More accurate information is obtained by interposing between the patient and the observer a plumb line, adjusted to correspond with the gluteal cleft. That curves must be "assumed to begin and end" where they pass under the string is liable to give rise to error, for it often happens that the junction of the curves does not

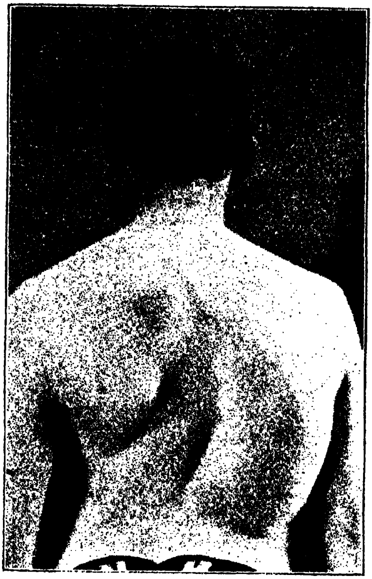

FIG. 294.—Severe Right Dorsal and Left Lumbar Scoliosis in a muscular adult, aged 22 years.

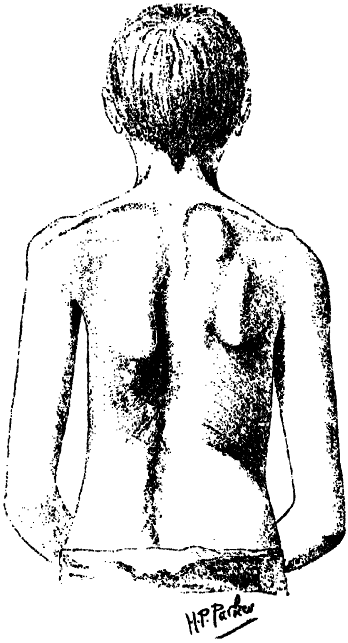

FIG. 295.
Scoliosis. Three Curves are present.

lie under the plumb line. In actual practice, if the tips of the spines are marked out, it is easy to judge of the presence and extent of a curve or curves—a convexity cannot well be mistaken for a concavity; but too much importance in any case must not be attached to mere deviation of the tips of the spines, unless confirmed by signs of deviation of the bodies.

3. In addition to the long C-curves, functional or structural, and simple shorter structural curves, and the typical S-shaped

[1] Lovett, *Lateral Curvature*, p. 47.

organic curves, cases are met with in which three or more curvatures are present (Fig. 295).

4. Some cases of scoliosis are associated with posterior projection of the spinous processes at the spot where the upper and lower curves meet (Fig. 296), especially when two curves nearly equal exist.

The spines project because, where the upper curve passes into

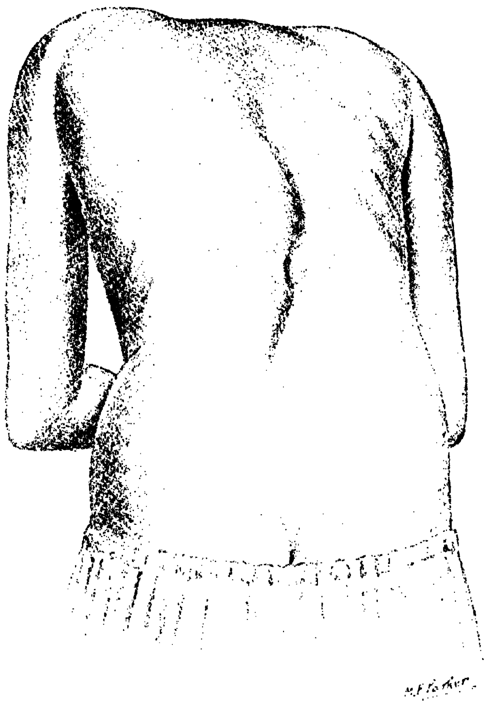

FIG. 296.—Scoliosis with Projection of two Spinous Processes at the Intersection of the Curves. The flexibility of the back negatived all suspicion of Pott's Disease (Mary W——, aged 14 years).

the lower, rotation is at its minimum, is in fact absent. The meaning of this will be apparent later.

The chief interest of this class of case lies in the following facts:—

Projection of the spinous processes is a constant accompaniment of Pott's disease, and lateral deviation is an occasional feature. Lateral deviation and rotation of the vertebræ are the distinctive

features of scoliosis, and projection of some spinous processes an occasional occurrence.

Some cases of scoliosis are accompanied by considerable pain, which gives rise to reflex contraction of the muscles, so that the

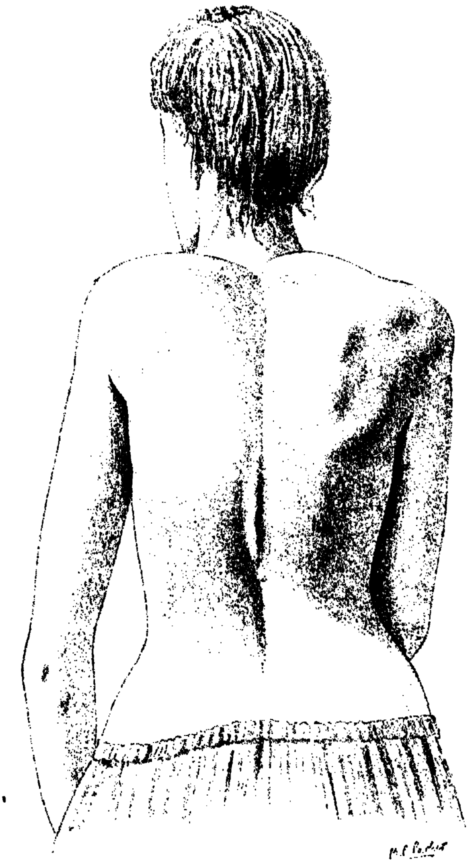

FIG. 297.—Back view of a woman, aged 22 years, with long C-Curve to the left in the Dorsal region, Prominence of the Spinous Processes in the Dorso-Lumbar region, and a small curve to the right in the Lumbar region.

diagnosis between it and Pott's disease is by no means always easy. When doubt exists, it is advisable to make more than one examination, and watch the development of the case.

X-rays are of little assistance, since it is only at quite an early stage, before any typical deformity of the bones has arisen,

that doubt is possible. It is true that the difficulty very seldom arises to those experienced in spinal cases, still from time to time even the most expert are at a loss to give an immediate diagnosis.

5. The effect of the distortion on the normal antero-posterior spinal curves must be noted. This varies with the individual case. The most frequent condition is exaggeration of the normal dorsal kyphosis, that is, a "kypho-scoliosis" exists in this region. Instead of exaggeration, the normal curve may be obliterated or even reversed (Figs. 297 and 298). Lüning and Schulthess illustrate a specimen [1] of marked lumbar kypho-scoliosis with a compensatory dorsal lordo-scoliosis. The opposite condition, namely, a lumbar lordo-scoliosis, may be primary; or it is secondary, in order to compensate a dorsal kypho-scoliosis. Riedinger[2] has dealt especially with this aspect of scoliosis and its significance.

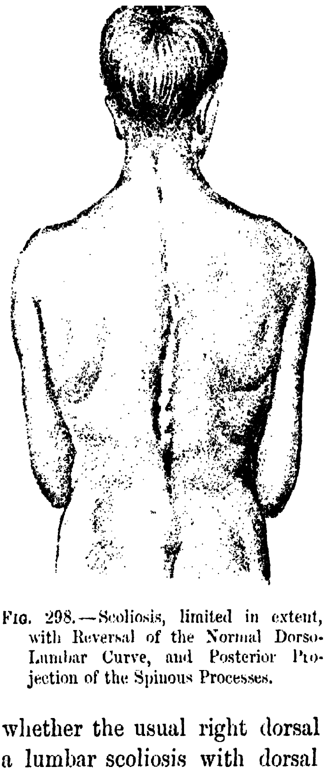

FIG. 298.—Scoliosis, limited in extent, with Reversal of the Normal Dorso-Lumbar Curve, and Posterior Projection of the Spinous Processes.

Some writers divide spinal curves into primary and secondary, and state that it is possible to distinguish between the two by suspension, the curve which yields being the secondary or compensatory one, while the less yielding or more fixed is the primary. Still, such a distinction is highly theoretical, as is shown by the want of agreement between experts, as to whether the usual right dorsal and left lumbar S-shaped curve is a lumbar scoliosis with dorsal compensatory curve, or the reverse. Fortunately, at all events therapeutically, the point is of minor importance. What we want to recognise is which of the curves is the predominant one. With a large dorsal and small lumbar curve, the dorsal curve is that which is important from the point of view of ætiology and treatment; and if the lumbar curve be large and marked, and the dorsal curve of equal size or less, then we regard

[1] Lüning and Schulthess, *Orth. Chir.* p. 233.

[2] Riedinger, *Morphol. u. Mechanismus der Skoliose.*

the lumbar curve as the more important. Therapeutically, the fact whether a curve is entirely, partially, or not at all redressible is of importance.

Schulthess[1] classifies scolioses into simple and multiple curves. The simple according to the region involved are named :—

Scoliosis-totalis
,, cervicalis
,, cervico-dorsalis
,, dorsalis
,, dorso-lumbalis
,, lumbalis
,, lumbo-sacralis
,, sacralis

dextro-convexa
or
sinistro-convexa.

He adds to these designations the adjective "lordotica" or "kyphotica."

Multiple curves are similarly described. Thus "scoliosis dextro-convexa dorsalis kyphotica, sinistro-convexa lumbalis lordotica" is an example of nomenclature that has the merit of accuracy, but not of brevity.

Position of the Bend.—A table given by Schulthess[2] shows that, (*a*) taking all the cases together, scoliotic bends occur most frequently in the neighbourhood of the twelfth dorsal vertebra; (*b*) left convex curves markedly preponderate. Leaving out those cases of compensated dorsal curvatures, the proportion of primary left curves to right is as 547 to 242. In men the disposition to left convex is more marked than in women, and the curve is usually higher up, while lumbar scoliosis is more often seen in females than in males. (*c*) Convex right-sided curves are most marked about the level of the seventh dorsal vertebra; left dorsal bends show a more even distribution over the dorsal area. (*d*) Right convex scolioses have more tendency to form compensatory curves; (*e*) left convex curves have less tendency to do so.

We will resume more fully the study of the clinical types later, as they will be more easily understood if we first discuss—

I. The pathology and morbid anatomy of scoliosis.
II. The methods of measuring and recording spinal curves in the patient.
III. The symptoms of scoliosis in general.

[1] Joachimstal's *Handb.* 3. Lief. p. 615. [2] *Ibid. op. cit.* pp. 806-809.

Then we shall pass on to discuss—

IV. Clinical types more exhaustively, since we must study the condition more fully before speaking of its causation.

V. Ætiology.

Morbid Anatomy and Pathology

Examination of specimens of scoliotic vertebral columns shows that—

I. The spine is bent or curved laterally.
II. It is twisted on its long axis.

I. The character of the lateral bend varies. One long gentle

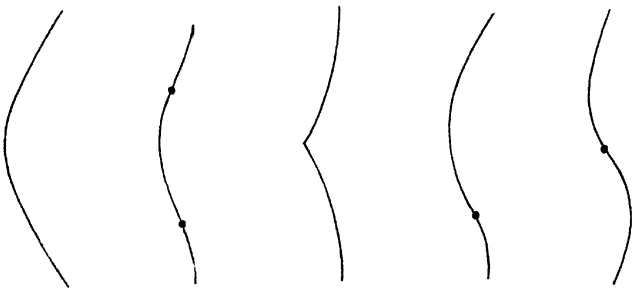

Fig. 299. Fig. 300. Fig. 301. Fig. 302. Fig. 303.

Outlines of Elastic Rods under Stress.

curve may be present, the so-called total or C-curve; or a localised simple curve, involving a section only of the spine, may exist; or the curvatures may be multiple, for example a double curve, something like an italic *ƒ* in shape; or in severer cases the gently sinuous *ƒ* may have developed into a marked S-shape (Fig. 294), and the curve and counter-curve may be more or less equal.

Again, one leading curve may be present in the mid-region of the spine, and opposite curves, less in degree, exist above and below the chief one; for example, a large convex right lower dorsal, compensated by a smaller convex left lumbar and left cervico-dorsal.

In very severe cases the bend may become so acute that it loses its sinuous character altogether and becomes angular.[1]

It is interesting to compare these types of bends with the behaviour of an elastic rod curved by superincumbent pressure.

[1] Cf. Riedinger, *op. cit.* fig. 2, p. 8.

In Fig. 299 the ends of the rod are free; in Fig. 300 they are able to move in a telescopic direction; in Fig. 301 loading is pushed to the breaking point; in Fig. 302 the lower end is clamped and the upper is free; in Fig. 303 the mid-point is fixed. Experiments on these lines have been performed by Beely, Schanz, Schenk, Schulthess and others, and a certain amount of parallelism between the behaviour of the spine and an elastic rod is admitted. Further, these experiments suggest that alterations in the type of curve might be expected with lapse of time.[1] This to a certain extent is so.

It is important to remember that the sacrum and coccyx are integral portions of the spine, and in speaking of spinal curvature observations must not be limited to the supra-sacral portion only.

II. On looking at Fig. 304 it will be seen that at the summit of the lumbar curve it is not the front of the 4th lumbar body which looks forward, but the right side of it, and this vertebra is rotated approximately 90° to the left. Similarly in the dorsal region the 9th, 10th, and 11th show a high degree of rotation to the right. The spine is twisted, like a wet towel wrung out by a washerwoman, to the right in the dorsal region, to the left in the lumbar. In other words, the bodies are rotated to the convexity of the curves. This is usually spoken of indifferently as "rotation" or "torsion." Some authors restrict the term "rotation" to the alteration in position of the bodies, and "torsion" to the consequent changes in their structure. Comparatively recently the terms "convex-torsion" and "concave-torsion" have come into use. We shall deal with this in due course, but we may at once say that concave-torsion is highly problematical and has never been demonstrated in any *specimen* yet. The nearest approach to this is the cast figured by Schulthess (*Zeit. f. orth. Ch.* xiv. 3 and 4, p. 489). Rotation or torsion is well illustrated in the region of the 4th lumbar vertebra of Fig. 304;[2] and on comparing Fig. 305 with this, it is clear that the deviation of the column of bodies is more marked than that of the arches and processes. All scoliotic specimens, whether of kypho- or lordo-scoliosis, or showing exaggeration or reversal of the antero-posterior curves, demonstrate two leading facts:—

A. The column of the bodies is more curved laterally than is the line of the tips of the spinous processes.

[1] We no longer regard osseous structure as immutably fixed, in fact it is in young life more plastic than some of the so-called soft parts.

[2] In this specimen note the presence of six lumbar vertebræ. This, in view of the recent work on congenital scoliosis, especially that of Max Böhm on the association of scoliosis and numerical variations of the vertebræ, is of importance.

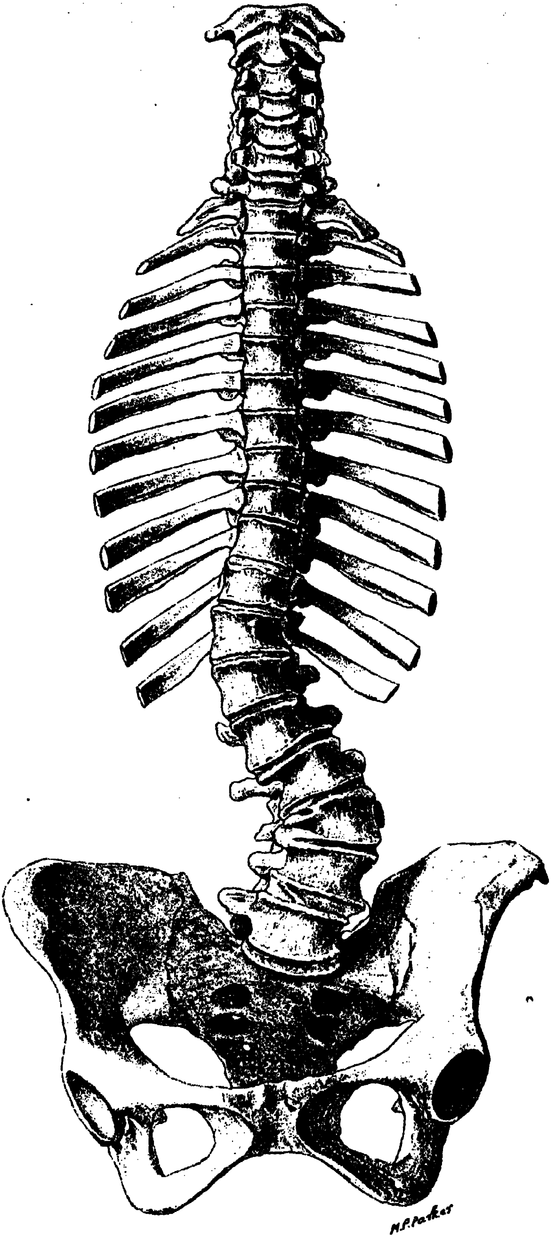

FIG. 304.—Front view of the Spinal Column. The extreme rotation of the lumbar vertebræ and wedge-shaped deformity of the vertebral bodies is well seen. This is also an example of Congenital Scoliosis. There are six Lumbar Vertebræ (Guy's Hospital Museum). The figures 304 and 305 show that the deviation of the spinous processes is not a measure of that of the bodies.

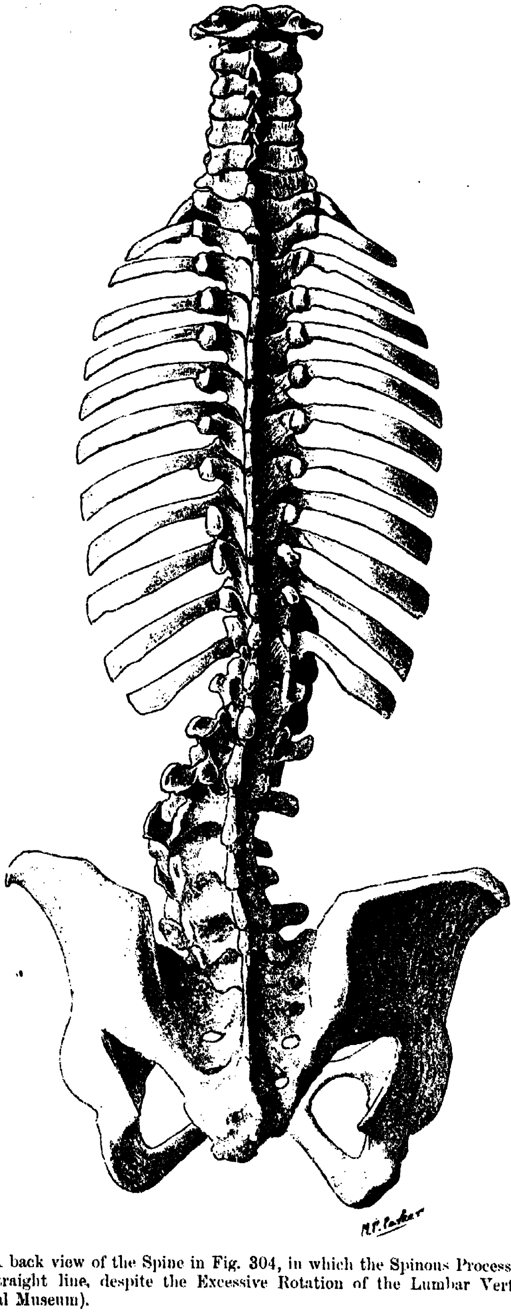

FIG. 305.—A back view of the Spine in Fig. 304, in which the Spinous Processes are almost in a straight line, despite the Excessive Rotation of the Lumbar Vertebræ (Guy's Hospital Museum).

B. The bodies are always rotated towards the convexity of the curve, or curves.

These remarks afford the clues to the changes in the structure of the individual vertebræ; but, before describing them we had better discuss briefly the difficult point of the mechanics of "rotation."

If a curved elastic rod—curved, say, in an antero-posterior plane

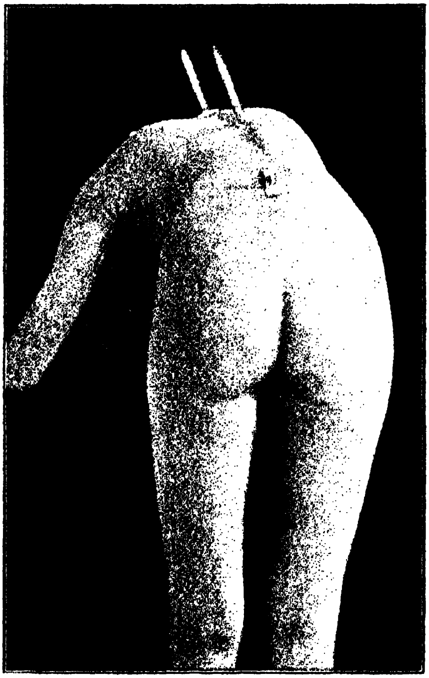

FIG. 306.—Model Flexed and Bent to the Left. The cardboard indicators have turned to the left (Lovett).

—is bent laterally as well, it twists on itself, that is, it rotates. A straight elastic rod can be bent in any direction, and it simply bends without any twist about its long axis; but if while curved in one plane it is deflected into another, torsion inevitably results.

The spine is a curved elastic rod, its curvatures being antero-posterior. Lateral flexion, then, must be accompanied by rotation.[1]

[1] This has much in common with Schulthess' view. He says that, having regard to the fact that the spinal column, when looked at sideways, is asymmetrical, lateral bending *must* be accompanied by rotation.

Pure lateral flexion does not exist. Following up this idea Lovett has studied the behaviour of the spine, in the living model, the cadaver, and, most interesting of all, in the column composed of the vertebral bodies and discs only, that is, in a spine stripped of its arches. He finds that there is little difference in its behaviour as the conditions are changed.

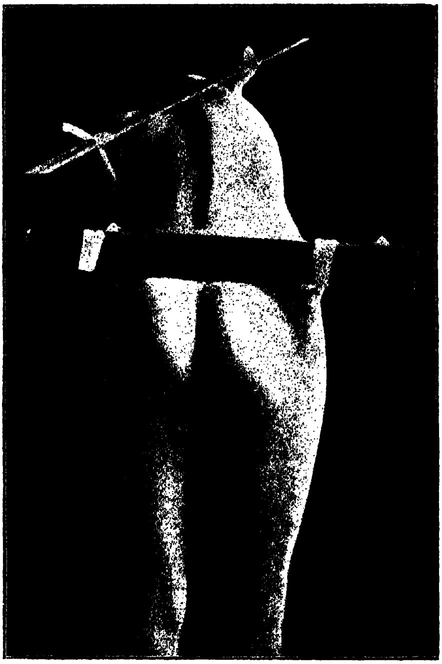

FIG. 307.—Model with Spine Flexed and Bent to the Left. The boards show the planes of the chest and pelvis. The board marking the former has rotated backward on the convex side of the curve (Lovett).

In connection with our present purpose his more important conclusions are that in the *normal* spine:—

1. Side-bending, in the erect position, is chiefly a lumbar movement, and is accompanied by rotation of the bodies of the vertebræ to the concave side of the curve.

2. Side-bending in the flexed position of the spine is chiefly a movement of the dorsal region, and is accompanied by rotation of the bodies to the convex side of the curve (Fig. 306).

3. In flexion of the whole spine, side-bending is accompanied

by rotation of the vertebral bodies to the convexity of the lateral curve, the characteristic of the dorsal region (Fig. 307).

4. In the erect position and in hyper-extension of the whole spine, side-bending is accompanied by rotation of the vertebral bodies to the concavity of the lateral curve, the characteristic of the lumbar region.

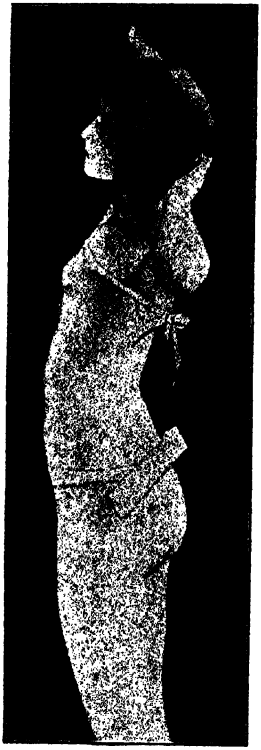

FIG. 308.—Side Bending to Left. Model Upright (Lovett). The board marking the plane of the chest has rotated backward on the left side.

But two of Lovett's contentions, viz. that side-bending in the erect position is chiefly a lumbar movement, and that the type of rotation in lateral flexion in the upright, or more still in the hyper-extended position is concave, do not appear to be borne out by his own illustrations.

Thus the side-bending in the erect position certainly looks rather a dorsal than a lumbar movement [1] (Fig. 309). As to the rotation, the pointers in Fig. 309 show less deviation in the lumbar region than elsewhere; whereas if Lovett is right they should show the deviation plainly at the site of the torsion, viz. in the lumbar region. In any case, the conclusions arrived at by Reiner and Werndorff [2] incline one to distrust the "pointer" method. They show that the combined movements of rotation about a frontal axis (flexion) plus rotation about a sagittal axis (lateral flexion) give rise to an appearance of rotation about a longitudinal axis, but that this is really delusive. And on carefully repeating certain of the experiments, but producing the bend by vertical loading, which must be more accurate than by mere pulling aside,[3] they always obtained—no matter whether the lateral flexion was combined with lordosis or kyphosis—convex rotation.

Lorenz shows, too, that in Fig. 308 the projection backwards of the upper board on the left is due to the thickness of the scapula and its muscles intervening,[4] and he gives a similar example with the error intensified; while in another figure he shows that if this error is obviated, convex torsion, not concave torsion,

[1] And if this is so, and if Lovett's pointers are reliable, this figure shows that lateral flexion takes place in the dorsal region, and that concave rotation is a dorsal phenomenon too.

[2] *Zeitschr. f. orth. Chir.* xiv. 3 and 4, pp. 531-542.

[3] Lovett, *ibid.* fig. 26.

[4] *Zeitschr. f. orth. Chir.* xix. 1 and 2, p. 181.

is present. He carefully repeats the experiments on models and concludes: "Therefore we cannot accept Lovett's formula according to which concave-torsion is an appearance, accompanying inflexion of a lordotic segment."

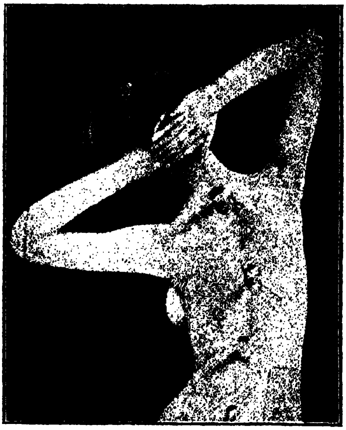

FIG. 309.—Side Bending to the Left. Model in Upright Position (Lovett).

Highly interesting and suggestive as Lovett's work is then, we are not prepared at present unreservedly to accept his conclusions. Certainly, if the isolated column of bodies (that is, the spine with the pedicles cut through) behaves like the spine in the model, and in the intact cadaver, the problem becomes immensely simplified, since all discussion about the action of the articular processes will be unnecessary. It does not seem reasonable to infer that the direction of the articular facets can have no effect on guiding and limiting movements.

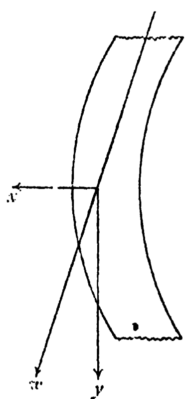

FIG. 310.—To illustrate Convex Rotation in Scoliosis. *w*, Body-Weight, split into its two components *x* and *y*.

In the *normal* spine, according to Lovett, anteflexion plus lateral flexion is accompanied by marked convex rotation; while lateral bending in retroflexion is accompanied by concave rotation —an observation which has not been accepted widely, and has been definitely contradicted by Lorenz, Werndorff, and Reiner.

We now come to **rotation in scoliosis**. Even if we could accept Lovett's conclusions *in toto* as to the behaviour of the *normal* spine, they do not help us in this matter, since in scoliosis, rotation in lordotic as well as in kyphotic segments is always *convex*.[1]

The cause of the convex rotation in scoliosis.—The body-weight *w* (Fig. 310), acting through a laterally curved spine, may be split into two components, *x* and *y*. *x* tends constantly to displace further the vertebræ to the convexity of the curve, and the brunt of the body-weight is borne by the column of the bodies, which are therefore displaced more

[1] Cf. Fig. 304, where extreme convex rotation, though no kyphosis, exists.

than the unweighted and muscularly held arches and processes. That the articular processes do not support weight is evident from the almost vertical position of the articular surfaces in certain regions, and also by the fact (mentioned under Pott's disease) that destruction of the bodies is not always followed by kyphosis, since in certain regions the arches can settle down closer together. The net result—that the bodies tend to displace, whilst relatively the arches do not—is that convex rotation is set up. That is to say, we are not prepared, on account of Lovett's valuable researches, to abandon the results of Judson's well-known experiment. Lovett's own statements on this matter are not clear. He says (*Lateral Curvature*, p. 77): "In addition to the lateral deviation in scoliosis, the curved region is rotated or twisted on a vertical axis, the bodies of the vertebræ *always* turning toward the *convex* side of the lateral curve. This rotation is the *mechanical accompaniment* of the lateral curve, and one cannot exist without the other." This certainly suggests that he considers the movement as somewhat analogous to what we have described as his views on the rotation in the normal spine. Yet on p. 44 he says on "Bony rotation": "The reason for this seems to be fairly plain. A permanent curve is forming, we will say, convex to the left; the vertebral bodies in their growth will follow the line of least resistance; and if they are plastic, they will expand where the pressure is least, and become compressed where it is greatest. They will turn away from the line of weight, which is obviously nearer the concave than the convex border. . . . If they were to turn toward the middle line instead of away from it, they would encounter the greater resistance and have to raise the whole weight of the parts above them. . . ." With the latter we entirely agree. Although Lovett's experiments in the normal spine, in which he shows that the column of vertebral bodies behaves the same as in the intact spine, may have "much significance in connection with the rotation theories of V. Meyer and Albert"[1] in scoliosis, the altered relation of the arches to the bodies (torsion) indicates that the effect of the articular processes must not be disregarded (see also p. 425).

Lovett, in spite of his remark (*Lateral Curvature*, p. 77) "always turning towards the convex side," teaches that scoliosis may be—

I. Functional, total, or postural, showing "reverse rotation," "concave torsion," "retrotorsion" (*ibid.* p. 51).
II. Transitional curves.
III. Structural curves, with convex torsion.

Yet he says (*ibid.* p. 48): "It is a progressive affection passing over only one sharp line, the transition from postural curves to structural or

[1] They who may be interested in reading the views as to the part played in spinal movements by the articular processes and ligaments, may consult the following references:—

Meyer, *Zur Mechanik der Skoliose*, Virchow's *Arch.* Bd. xxxv., 1865. Also *Die Statik und Mechanik des menschlichen Knockengerüstes*, Leipzig, 1873.

Albert, *Die skoliosischen Wirbelsäule*, Wien, 1899, p. 37.

Merkel, *Handbuch der topographischen Anatomie*, Bd. ii., 1896.

organic ones." We do not understand this. Are transitional curves the "sharp line"? But since concave torsion is only met with clinically, if at all, we cannot discuss it further here. Lovett himself says that with the occurrence of convex-sided rotation, the beginning of pathological changes is to be accepted[1] (*Zeitschr. f. orth. Chir.* xiv. 3-4, p. 442). It follows, then, that the conditions mentioned under I. and II., p. 421, can have no "pathology" proper.

Although we have laid great stress on the body-weight as the cause of rotation, the effect of longitudinal muscular tension in intensifying this must not be forgotten. Indeed, in quadrupeds this latter is the chief factor. The convex rotation is well shown in the case of a pig in Fig. 493, Joachimstal, *Chir. Orth.* 3. Lieferung.

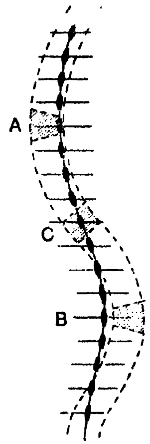

Fig. 311.—A Diagram to illustrate the Effects of Rotation on the Column of the Vertebral Bodies (viewed from behind). The dotted lines represent the column of the bodies, and the dark dotted line the position of the spinous processes, while rotation of the bodies is present. At A is the summit of the curve of the bodies to the left, at B to the right, and C is the intersection of the curves.

Rotation, then, is always convex, and is the expression of the fact that the column of the bodies is more curved than the line of the spines. It follows that the difference will be most marked at the summits of the curves, where the structural rotatory changes will also be most striking. The state of affairs is very diagrammatically illustrated in the figure (311), in which a scoliotic spine with a double curve is viewed from the back. At A and B the bodies are twisted to the left and right respectively, and displacement laterally reaches its maximum both absolutely and relatively to the spines. And although at C there is no lateral displacement, the right-handed twist and left-handed twist meet and "longitudinal torsion" is at its maximum. Practically "rotation" or "horizontal rotation" and "longitudinal torsion" are part and parcel of the same thing; and we would have spared the reader the complication of terms but for the fact that there is still another "torsion" to be differentiated. This too depends on the rotation.

At the point C a vertebral body is represented tilted over at an angle of about 45°, while the transverse processes are shown

[1] As Lovett puts it, "With the appearance of convex bony rotation we must consider that pathological alterations have commenced. This pathological change consists in the compression of the osseous structure in the concavity of the curve" (*Boston Med. and Surg. Journ.*, June 14, 1900).

approximately horizontal. There is then a twist at this point in the structure of the spine about a sagittal axis. This is known as "sagittal torsion."

Changes in the Vertebral Column

We are now in a position to discuss the changes seen in the individual vertebræ. These are those due to—

I. The lateral bend.
II. The rotation (or longitudinal torsion).
III. The sagittal torsion.

Only the more important points will be dealt with, and these very briefly.

The Vertebral Bodies. (*a*) *Wedge Vertebræ.*—On the concave side of the curve these are compressed, and on the convex relatively, or in very marked cases absolutely, expanded. The more acute the bend, the more marked the wedging. It may be that the apex of the curve is occupied by one pre-eminently wedge-shaped vertebra (cf. 4th lumbar vertebra, Fig. 304), or the wedging is less marked and more evenly distributed over several *vertèbres cunéiformes* (cf. the right dorsal curve, Fig. 304).

The bony structure transforms more than the soft parts, the summit of the bend in cases of marked distortion being occupied by a vertebra, and not by a disc. The disc in marked cases is squeezed out on the concave side of the curve, and here the vertebral bodies become synostosed together. The apical vertebra may become so reduced on the concave side that the ones above and below nearly meet (cf. 3rd and 5th lumbar vertebræ, Fig. 304), or they may quite do so. (In specimen 2103, Hunterian Museum, the 8th and 10th dorsal vertebræ have met and are synostosed.) In marked but still rounded bends the synostosis may extend, in the concavity, over several vertebræ.

(*b*) *Lozenge-shaped Vertebræ.*—This is a distortion by no means so regularly and constantly met with as the foregoing. Whilst wedging is *the* typical deformity of scoliosis, the rhomboidal or lozenge-shaped, oblique, or Schräg-wirbel, is only met with in a marked form at the junction of opposite (primary and compensatory) curves. Hence its designation of "Interferenz-wirbel," and its occurrence in marked S-curves; whilst it is only feebly developed towards the beginning and end of simple curves.

It is due to the upper and lower surfaces sliding on each other from the action of the body-weight, whilst at the same time the effects of rotation and counter-rotation become marked as longitudinal torsion.

FIG. 312.—Striae on the Bodies of Scoliotic Vertebræ (Rédard).

This will be readily comprehended if Fig. 312 is kept in view. The "torsion" effects show as the oblique striæ on the body of the 1st L. Vertebra, and the "sliding" is intensified by the prolongation upwards of its under surface.

Pedicles.—On the convex side they become more sagittal or antero-posterior in direction; on the concave side more transverse or frontally directed.

In the concavity of the curve they take part in the general atrophic tendency. Their level is altered as we have explained in dealing with sagittal torsion.

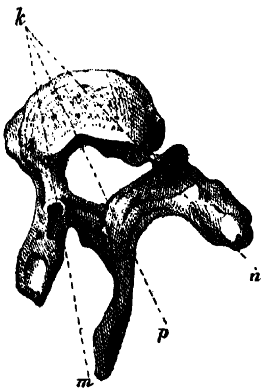

FIG. 313.—A Dorsal Vertebra from a case of Scoliosis, Convex to the Left, Atrophy of the Pedicle on the Concave Side. The Body of the Vertebra is irregularly oval (after Lorenz).

The Vertebral Foramen, as a result of the displacement of the pedicles and arches, loses its shape and becomes pointed in the concavity, and more rounded in the convexity (Fig. 313). The change is not of importance from the point of view of compression.

The Transverse Processes undergo a similar displacement to the pedicles, that is, the process on the convex side becomes more antero-posterior. One result of this is that the vertical furrow between the transverse process and spines is narrower on the convex side than on the concave (Fig. 313).

The Spinous Processes.—The direction of the spinous process is an important matter, yet its adequate discussion would take up so much space, that, owing to the technical nature of the subject, it would be difficult to be at once brief and clear.

The general state of affairs is that represented by Figs. 304 and 305. (*a*) The spines deviate less than the bodies. This, in the region of the wedge vertebræ, results in a tendency of the spinous process to point to the convexity of the curve.[1]

(*b*) The rule is that the curved line formed by marking on the skin the tips of the spinous processes is the same in direction as the curve of the bodies, only less in degree.

By Joachimstal (*Handb.* 3. Lief. pp. 656-663), Lovett (*Lateral Curvature*, pp. 81-82), and by Schanz (*Zeitschr. f. orth. Chir.* xiv. 3-4, pp. 447 *et seq.*), the subject is fully dealt with. And, the author is inclined to agree with Lorenz that too much reliance must not be placed on the line of the tips of the spines. It may show a slight lateral curve, when in reality there is no curve of the bodies, and, as we have said, it shows only a moderate curve when very severe curvature of the column of the centra is actually present. In fact, we must judge of the presence or absence of curvature, not from the line of the spines at all, but by rotation signs, *e.g.* rib-prominence backwards on one side. And we may go further still, and add that if the rotation signs indicate, say, curvature to the right, whilst the line of the spines suggests curvature to the left, we must accept the evidence of rotation, and disregard the line of the spines. That is to say, the exceptional cases described as concave-rotation do not exist in reality, they are only apparent, and are due to undue importance being attached to the line of the spines (Lorenz, "Über Konkavtorsion," *Zeitschr. f. orth. Chir.* xix. pp. 172-207).

(*c*) In a typical case the spinous process is curved (see Fig. 313), so that its root deviates concavewards, and towards the tip the inclination is convexwards.

(*d*) In addition it may be twisted on its long axis, and its inclination altered.

Articular Processes.—One cannot fail to be struck, in examining specimens of scoliosis, with the great frequency of synostosis in the regions of the joints of the articular processes and between the laminæ, due in the latter position to ossification of the ligamenta subflava. The most favourable conditions for synostosis occur at the articular surfaces, and it is here that it is seen earliest. Synostosis of the arches leads, of course, to altered mechanical conditions, and

[1] Cf. Riedinger, *ibid.* fig. 80, and Lovett, *ibid.* fig. 64.

once more emphasises the fact that it is very difficult to import considerations concerning the behaviour of the normal spine into scoliosis.

Synostosis of the articular processes and laminæ is followed by that of the bodies in the manner already indicated.

A suggestive point is the behaviour of the articular surfaces at an earlier stage than the above. The joints on the concave side are enlarged and the cartilage at first thickened. The changes, as both Schulthess and Lovett [1] agree, rather suggest that these processes do not play an entirely passive rôle in the mechanism of scoliosis.[2]

Costo-Vertebral Joints.—They are deepened on the convexity, and become shallow on the concavity. They are more posteriorly placed than normal on the convex, and more anteriorly on the concave side.

Ligaments.—The anterior common ligament is bunched up into a thick cord, with a well-defined border on the concavity, and becomes thinned out and lost on the convexity. The posterior common ligament does not suffer this lateral displacement towards the concavity, at least not to the same degree as the anterior.

Muscles.—Structural alterations are only found in long-standing cases, save in those quite exceptional instances where primary muscular lesions are the causes of the curvature. In slight degrees of scoliosis changes in the muscles have not been observed; but in severe degrees the structural changes are due to immobilisation of the segments of the spine, and the resulting inactivity of the muscles acting on the part. Thus in the concavity of a severe case the muscles are more or less atrophied, and are often replaced by fatty tissue, especially in their deeper layers. Hence they are seldom rigid, prominent, or contractured. Their condition is that of atrophy from disuse. On the convex side the muscles undergo in many cases a fibrous degeneration where they are stretched over the bones.[3] The muscles on the convex side may be wasted and thinned, and occasionally fatty degeneration is found here also. In severe cases, displacement of some of the bundles of the longissimus dorsi over the spinous processes has been seen. That is to say, the dislocated strips, belonging normally to the convex side, are found stretching across the concavity; and by their contraction they must increase the deformity.

In connection with the muscles we may mention the altered

[1] Lovett, *ibid.* p. 81; Schulthess, Joachimstal's *Handb.* 3. Lief. p. 665.
[2] See also vol. i. p. 420. [3] Schulthess, Joachimstal's *Handb.* 3. Lief. p. 696.

position of the diaphragm. This becomes oblique, and is lowered on the convex side of the dorsal curve.

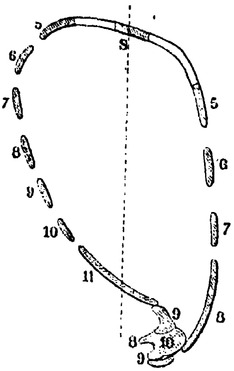

FIG. 314.—Diagram to illustrate the Position of the Ribs when the Curvature is right dorsal (Rédard).

THORAX

In a simple curve, quite low down, thoracic changes are practically absent. In the usual lumbar curve the transverse axis of the lower part of the thoracic cage is displaced relatively to that of the pelvis.

When the dorsal vertebræ are curved, the effects on the thorax become marked and interesting.

Figs. 314, 315 show that in a right dorsal convex curve the thorax is twisted in the opposite direction, viz. to the left. It is also flattened in its left oblique diameter, or its left oblique diameter becomes subnormal, and the right oblique supernormal. In general terms, it is compressed along that oblique diameter whose posterior

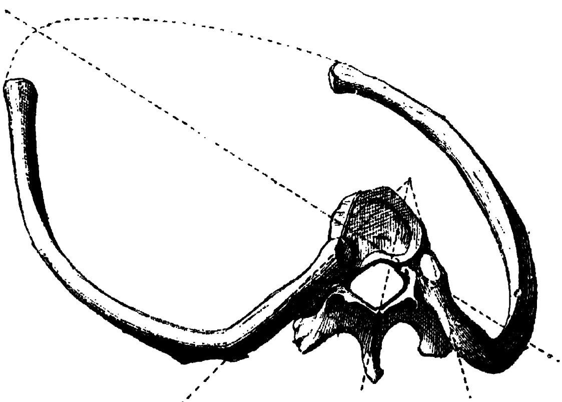

FIG. 315.—Illustrating the Alterations in the shape of the Ribs, and of the Direction of Transverse Diameter of the Thorax in a right dorsal Scoliosis (Rédard).

extremity corresponds to the concavity of the spinal curve. This, together with the fact that the vertebral ends of the ribs must follow the changes in position of the transverse processes, explains the changes in the ribs. On the concave side the rib-angle is

opened out and its curvature anteriorly increased; on the convex side the rib is bent in at the angle, and anteriorly its curvature is flattened out.

The obvious effects are—

(*a*) That on the convexity a series of the sharp rib-angles

FIG. 316.—Front view of the Bony Framework of a chest from a case of right dorsal and left lumbar Scoliosis (Guy's Hospital Museum).

project posteriorly, forming the rib-prominence, so important in diagnosis; while in the concavity the ribs fall away.

(*b*) Anteriorly, the mammary region corresponding to the concavity becomes unduly prominent.

As shown in Fig. 317, on the convex side the ribs become more inclined, on the concave they tend to run horizontally.

We cannot go minutely into the displacement of the sternum and rib cartilages. Speaking widely, the sternum, like the tips of the spines, resists displacement from the mesial line. Fig. 316

FIG. 317.—Back view of Fig. 316. Note the exaggerated Obliquity of the lower right ribs (Guy's Hospital Museum).

illustrates a further point, viz. that the thorax remains far more constant in form than the spine, a fact quite opposed to expectation unless we bear in mind that bone distorts less readily in certain cases than the soft parts.

As a rule there is only one rib-prominence, but two, or even three may be met with. The last event is rare since it necessitates

an acute S-bend, with compensatory curves above and below, within the region of the rib-bearing vertebræ.

The shoulder-girdle follows the changes impressed upon the upper thorax.

Pelvis

Scoliosis may give rise to pelvic obliquity (see Fig. 304), which in extreme cases gives rise to obstetrical difficulties.

The sacrum shows signs of—

1. Lateral curvature.
2. Rotation, or rather longitudinal torsion.

1. *Lateral Curvature of the Sacrum* is not usually well marked. It is best seen from the front, or in the isolated sacrum by looking from above downward through the medullary canal.

It may be simple, as when it forms part of a simple lumbo-sacral curve; or S-shaped, the upper part of the sacrum taking part, for example, in a right sacro-lumbar curve, whilst the lower takes part in a left convex sacro-coccygeal curve.

2. *Rotation or Longitudinal Torsion* is the important point, since it is the cause of pelvic obliquity. Thus if the right sacral wing is carried forward and the left backward, then the right oblique pelvic diameter will be shortened and the left increased.

On referring to the effects of torsion on the thorax, it will be seen that in a right convex curve the right oblique diameter is lengthened, and in purely sacral curves a corresponding deformity is seen in the pelvis. In the lumbo-sacral simple curve the opposite condition may be met with.

The Skull.—Hoffa claimed that in long-standing scoliosis asymmetry of the face and the skull is observable, *i.e.* the distortion has extended from the spine to the cranium. We allude later to the cranial asymmetry of rickets.

Visceral Changes

The effects of the spinal distortion on the viscera must be briefly mentioned.

The diminution of space at the base of the right lung in the common right dorsal and left lumbar curves is associated with adhesive pleurisy, obliteration of the pleural cavity, and pulmonary collapse. According to Bachmann's statistics[1] pneumonic

[1] Joachimstal, *op. cit.* p. 698.

conditions are many times more frequent in severe scoliotics than among the general population. The same author points out that phthisis accounts for 19·7 per cent of the deaths in these cases.

As the respiratory organs are thus hampered, the heart is called upon to do more work in order to pump the blood through the diminished pulmonary area; but, owing to the curving and kinking of the aorta and the cardiac displacement present,[1] the heart itself is severely handicapped. The general result is right-sided cardiac hypertrophy and dilatation, leading to more or less severe venous stasis.

The trachea and œsophagus are displaced so as to follow the concavity of the curve as nearly as possible. The liver in right lower dorsal curves is pushed to the left, and the left half is better developed than the right. The kidneys are altered in position according to the type of curvature; that on the convex side may be dislocated or become floating, or compressed between the spine and the ribs, or even between the spine and the crista ilii.[2] Therefore cystic degeneration, granular kidney, simple atrophy and hydronephrosis are all common.

The spleen is generally higher than normal, and perisplenitis, atrophy, and cyanotic induration are stated by Bachmann to occur frequently. The position of the stomach is changed, the cardiac end is elevated and the pyloric depressed. The lateral displacement of the structures may so affect the transverse colon that it becomes almost vertical.[3]

[1] Bouvier, *Atlas des leçons cliniques*, Planche II. fig. 1, gives a case where the heart reached the level of the left clavicle. The author has seen the apex beat in the third right space.

[2] Joachimstal's *Handb.* p. 691.

[3] Visceral displacement is fully dealt with by Bachmann: "Die Veränderungen an den inneren Organen bei hochgrädigen Skoliosen und Kyphosen," *Bibliothek Med.* Abteilung i. f. 4.

Max David states that recently Wetzel has shown that syringomyelia may exist in scoliosis, due to stasis in the central canal.

Hoffa also cites the case of a girl aged eighteen, in whom a scoliosis, due to late rickets, developed rapidly, and complete paralysis of the right limb resulted.

CHAPTER IV

SCOLIOSIS OR LATERAL CURVATURE OF THE SPINE—*Continued.*

Examination and Record of Scoliosis—Scoliosometry—Symptoms and Course—Description of Types—Ætiology and Ætiological Types—Congenital Scoliosis—Ischias Scoliotica—Hysterical Scoliosis—Scoliosis and Diseases of the Nose, Naso-Pharynx, and Chest—Diagnosis—Prognosis.

EXAMINATION AND RECORD OF SCOLIOSIS

THE more severe forms can be recognised at a glance, but in slight cases it is easy to overlook the condition. It is not only the recognition of the deformity that is necessary, but we should have an accurate record of the state of the spine in order to ascertain whether it is progressing favourably under treatment, is stationary, or is becoming worse.

In dealing with cases of scoliosis, where the factors at work are often numerous and complex, many points must be inquired into and noted.

The Family History.—The occurrence of scoliosis in the family, and the history of any hereditary deformity are noted. It is often advisable to see the parents in order to ascertain if they themselves are normal.

Personal History.—The general health of the child in infancy, and any evidences of rickets, the date of onset of the curve, and whether it has increased rapidly or not, and the relative height and weight of the patient should be noted in order to see if they are up to the standard. It is important to observe carefully the general health, if the strain of school life is being borne well, and if the child is readily fatigued, either by mental or physical work.

The general condition of the patient is to be noted as to nutrition, colour, development of the chest, the length of the lower extremities, and the general attitude and carriage. Any

deformity of the lower extremities, such as genu valgum or flat foot, is of importance, and, in girls particularly, an inquiry must be made as to the manner of wearing the clothing, if suspended from the waist or from the shoulders. Any undue reserve or shyness, or what is commonly called nervousness or diffidence, and a constitutional laziness of temperament, are worthy of observation, such patients being especially difficult to treat satisfactorily.

Examination of the Back

The patient's back is bare, as low as the beginning of the gluteal cleft. It is convenient to have in the dressing-room a loose flannel skirt, which can be put on by the patient after the removal of the ordinary garments, and held in place just above the great trochanters by an elastic band. A jacket, with the opening and buttons behind, covers the front of the body.

The patient then stands in a good light with the back to the surgeon and the arms hanging at the sides. The examination must not be hurried. Two or three minutes should be allowed to elapse, as the patient gradually relaxes the efforts made in standing upright and assumes the position and attitude usual to her. The surgeon should not touch the patient during this time, as the contact of his hand stimulates the muscles, and he may receive a false impression of the state of the back. During the inspection the following points are observed :—

1. The outline of the body, whether symmetrical or not, particularly noting if one flank is more curved than the other, and if the arms make equal triangles with the trunk, also whether one hip is more prominent than the other. After any difference in the length of the legs has been corrected, it is very easy for an experienced surgeon to estimate the amount of asymmetry remaining, and he does so by noting the position of the two sides of the trunk with reference to an imaginary line prolonged upwards from the gluteal cleft.

In children, if the front of the chest is observed, the asymmetry is much more noticeable, as the outline of the parts is sharper.

2. The level of the shoulders is noticed next, and if one is higher than the other the patient should be asked to rectify the position. Failure to do so suggests structural scoliosis.

3. While the patient is at ease, the position of the scapulæ

should be observed and compared on the two sides. The tips of the spinous processes and the angles of the scapulæ may be marked out with a crayon or aniline pencil. A useful guide is a plumb-line suspended between the patient and the surgeon. It should be hung from a horizontal bar so that it can be moved laterally and made to coincide with the gluteal cleft.

4. The position in which the head is carried is remarked.

5. The physiological antero-posterior curve is observed, and any increase or diminution recorded.

In slight cases, particular attention is necessary to two points:— Any alteration in the outline of the flanks and flattening or prominence of the erectores spinæ. These signs are of great value.

6. The patient is now directed to cross the arms on the chest, with the hands resting on the opposite shoulders, and to flex the spine well. It is remarkable how much greater any deformity appears in this position. It "brings it out," as it were, and any deformity of the ribs is evident now that they are uncovered by the drawing upwards and outwards of the scapulæ.

We proceed to consider:—

1. The lateral displacement and its character.

2. The rotation present.

3. The amount of fixation present or flexibility remaining.

1. The Lateral Displacement and its Character.—As already suggested, the marked tips of the spinous processes may be compared with the adjusted plumb line.

We observe the presence of any lateral curve and the region and extent of the spine involved. We also note whether the spine, being deviated to one side of the mid-sacral line, returns again to this line, or whether it remains on one side of it, as in the overhanging types. A simple curve low down may be seen, then higher up the line comes back and runs up vertically; or the line of the spines may become median again after a very slight compensatory curve; or a marked S-curve is present.

But, whatever curve exists it is only an indication of, and in no sense a measure of the actual lateral displacement present. It is nothing more than the line of the tips of the spines. To judge of the severity of the curve of the bodies we must pass on to—

2. The Rotation Present.—In severe cases rotation, as

shown by the projection backwards of the ribs and transverse processes on the convex side, is easily seen even in the upright position. In slighter cases the patient should be directed to cross the arms on the chest, pull the scapulæ as far forwards as possible, and bend down until the trunk is nearly horizontal —the knees being straight. The surgeon then, standing either in front of or, better, behind the patient, and looking along the spine, is able to detect any prominence of the ribs or loin.

Posterior projection or asymmetry indicates rotation; rotation depends on lateral displacement; rotation is always convex-sided. Its degree, and locality, and extent then indicate the distribution and amount of the lateral curve of the column of *bodies.*

So-called Concave Rotation.—We have already said that in scoliosis the rib-prominence lies on the convex side of the curve, but certain observers have stated that exceptionally it may be otherwise. Kirmisson, writing on "scolioses paradoxales" (*Rev. d'orthop.* 1895, p. 218), Schulthess, Vulpius, and latterly Lovett especially, have maintained this. Thus they state that a left total scoliosis, in which the tips of the spines show a curve convex to the left, may show rotation backwards of the right ribs, that is, rotation of the bodies into the concavity of the curve. We have already dealt with this under pathology, and agree with Lorenz that if this is so the whole pathology of scoliosis would have to be re-written. But, pathologically such a condition as concave rotation has very slight support; and clinically these cases are open to another interpretation. The cases figured show only the slightest possible curve of the lines of the spines, and we have already given reasons why we consider the evidence obtained from the spines as less reliable and valuable than that obtained from the rotation signs. It may well be, as Lorenz suggests, that these cases are really S-curves, in which the evidence of the spines happens to be delusive. We would certainly only accept as cases of concave-rotation those showing structural and more or less permanent changes. We do not regard as scoliosis at all those cases thus described by Lovett, *Lateral Curvature*, p. 51:—"The position in a typical functional curve, total curve, is merely the physiological one necessitated in every spine made convex to the left, and can be produced experimentally by putting a book under the right foot. . . . The thorax and shoulders twisted back on the right, etc." Such functional curves—even if the rotation is concave, and about that there is doubt—are no more scoliosis than is the position adopted to compensate for a short leg, for example. Such a position may be pre-scoliotic in that a scoliosis may eventually ensue, but experience shows that often, even after years, on rendering the pelvis level the spine becomes straight promptly. This we regard as proof that no scoliosis existed. In the absence of definite pathological, and more conclusive

clinical evidence we are not prepared to discuss the matter further in this place.[1] On this point the following references are of value:—

SCHULTHESS. Zeitschr. f. orth. Chir. xiv. 3, 4, and xix. 1, 2, p. 47; Joachimstal's Handbuch, 3. und 4. Lief.[1]

KIRMISSON. Diff. acquises.

KIRMISSON and SAINTON. Rev. d'orthop., 1895, p. 218.

LOVETT. "Lateral Curvature," and more fully, Zeitschr. f. orth. Chir. xiv. 3, 4; Boston Med. and Surg. Journal, June 14, 1900; October 31, 1901; and March 17, 1904.

LORENZ. Zeitschr. f. orth. Chir. xix. 1, 2, "Über Konkavtorsion." Very full article, 35 pages.

SCHANZ. Zeitschr. f. orth. Chir. xiv. 3, 4, p. 471.

REINER and WERNDORFF. Zeitschr. f. orth. Chir. xiv. p. 530 *et seq.*

3. THE FLEXIBILITY OF THE SPINAL COLUMN.—The amount of flexibility is a gauge of the improvement that may be expected under treatment. It is tested by causing the patient to bend first to one side and then to the other, keeping the legs straight, whilst the surgeon fixes the pelvis with his hands on the ilia, or better still a pelvic rest may be used. It will be found that lateral flexion is more free on the concave side. On bending to the convex side the affected segment of the spine may straighten out somewhat, or be found obviously fixed. Inequality of lateral flexion on the two sides, then, is suggestive of commencing lateral curvature, the curve being convex towards that side on which lateral flexion is the more limited. Of course, in advanced fixed cases, with ankylosis of the laminæ and articular surfaces, although lateral flexion of the spine as a whole is more marked on the concave side, it is obvious that the appearances are due to movement of the uninvolved portions of the spine, and the structures affected are simply displaced *en bloc*.

This is a convenient place to emphasise Lovett's point, viz. in reality how limited spinal movements are even in health. The actual amount of lateral flexion of which a spine is capable is really much less than appears to be the case, the lateral flexion of the spine being intensified in appearance by the dropping of the shoulder on the concave side and by the lateral displacement of the pelvis. If the pelvis is fixed, and observation concentrated on the line of the spines only, the body outline being disregarded, lateral flexion will be seen to be surprisingly restricted.

The next step is to suspend the patient by means of some sling, such as Sayre's head sling. Just sufficient traction should be

[1] We shall refer to it again under "Clinical Varieties."

exerted to take the weight off the spine.[1] If straightening results the outlook is promising. The amount of straightening obtained probably represents the amount of improvement that can be expected apart from forcible methods of correction.

If the straightening and restoration of symmetry are complete, evidently no, or the very slightest, structural changes are present, and we are dealing with a case of bad posture which is not yet scoliotic. The prognosis of such pre-scoliotic cases, if suitably treated, is good.

A partial improvement may be due to the straightening out of less fixed compensatory curves, the chief curve remaining unaffected.

In short, the greater the mobility present in the affected segment of the spine the greater is the possibility of improvement.

Instead of suspension the effect of prone recumbency may be noted, but conclusions drawn from a spine in this position are of little use since they are subject to so many limitations.

The effects of the muscles passing to the shoulder girdle may be studied. Thus elevation of the arm on the concave side of the curve, the convex-sided hand pressing on the rib-prominence, or suspension by the hands—the rings or bars for either hand being at different levels—may be seen to have a corrective effect in sufficiently flexible cases. We shall refer to the "best possible position" again under "treatment."

The systematic examination of the patient in the manner above described informs the surgeon of the presence, form, character, regional distribution, and fixity of a curve or curves.

In addition, a skiagram may yield still further information, for example the presence of congenital anomalies of the vertebræ. It is not needed to diagnose scoliosis, but is a very valuable adjuvant in studying it.

During the examination, the surgeon will note the condition of the heart and lungs, the presence of venous stasis, and marked visceral displacement.

Record and Measurement of the Lateral Curve (Scoliosometry)

Mere inspection then enables one to ascertain the existence of scoliosis, the nature of the curve or curves, and the degree and

[1] Suspension by the arms introduces too many considerations concerning the attachments of the vertebro-brachial muscles. It is convenient, however, to cause the patient to grasp a horizontal bar so as to raise the scapulæ and uncover the ribs.

character of rotation present. To record accurately and measure such a case, however, we require some means of noting:—

1. The details as seen in a frontal projection. These are asymmetry in the outline of the trunk itself, and differences in the levels of the scapulæ, of the shoulders, and hips.

2. Any departure from the normal physiological antero-posterior curves, *i.e.* the outline as seen in a sagittal projection.

3. The outline of the trunk as seen in transverse section at varying levels, indicating the amount and direction of any rotation present.

Photography.—Photography is perhaps the most generally useful means at our disposal, but it requires considerable care to obtain accurate records, and on account of the absence of perspective, rotation is not depicted.[1]

The following rules must be observed:—

1. The patient stands at ease with the legs straight and the arms hanging at the sides in the relaxed position; this occurs at the end of about one minute.

2. The heels of the patient are on a line parallel with the lens of the camera, otherwise distortion is inevitable. This relation is measured and not left to guess-work. The simplest solution is to have a stand for the patient, which is provided with two leathers for the heels. It is always placed in a definite location, the relation of which to the camera is formulated.

3. The patient stands at a fixed distance from the camera in all cases if pictures are to be used as accurate records.

4. The light is oblique from behind, preferably diffused, and, if possible, not the direct light of the sky, for this gives contrasts too violent between the light and shadow. A light from overhead throws the shadow of the shoulders on to the back, and obscures the spinal furrow. A light directly from behind gives a flat wide picture without contours. A light directly from the side throws the shaded part of the body into such blackness that the body outline on that side is lost.

5. The shadows should be diminished by a white reflector on the side of the patient away from the light. This is easily obtained by the use of a common clothes-horse, one wing of which is covered with sage green, which serves as a background; while the other wing is covered with white to serve as a reflector. The patient faces the green surface, while the white surface is placed at the desired angle to throw the light on to the shaded side. By this arrangement contour may be secured in the picture.

The unsteadiness and swaying of the patient may be obviated by placing an ordinary photographic rest against the chest.

[1] Lovett, *Lateral Curvature*, p. 71. The rules to be observed are taken almost verbatim from Lovett's work on *Lateral Curvature*.

Taking the Outline of the Spine.—Lovett's method is to mark out first of all the spinous processes with the patient standing erect, and then to lay on the back a strip of crinoline gauze through which the spinal marks may be seen. They are then easily indicated on the gauze, and a permanent record of lateral deviation is obtained.

A good plan is to mark out the line of the spines, and photograph the patient with the precautions already suggested; and, in addition, to interpose between the patient and camera, but close to the former, a frame across which are stretched vertical and horizontal threads or wires at definite distances apart. This gives a chart

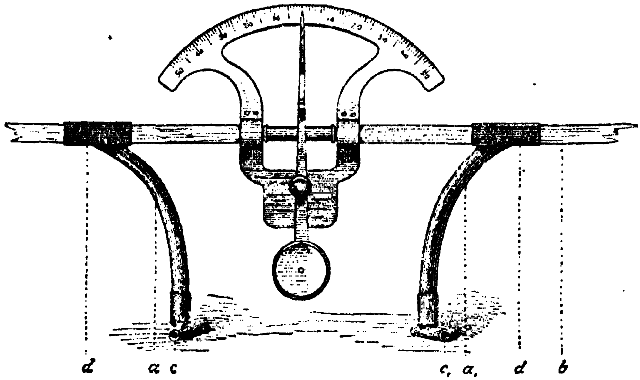

FIG. 318.—Schulthess' "Nivelliertrapez" or Level Indicator.

of the back with latitude and longitude as it were of the various points.

To Measure Rotation.—With the patient in the erect posture the horizontal contour may be recorded by the thoracograph of Demeny or Hübscher, or by Schenk's apparatus.

If the patient bends well forward the difference in the level of the ribs on the two sides is readily recorded by Schulthess' "Nivelliertrapez," or level indicator (Fig. 318). The pendulum-pointer, remaining always vertical, indicates the number of degrees the stand has to be canted in order to be adapted to the patient's back. It is useful, but does not differentiate between structural rotation and rotation due to muscular action.

Lovett considers that Feiss' appliance[1] is the simplest and fairly accurate in its results.

[1] *Boston Med. and Surgical Journal*, July 13, 1905.

The Contour Recording Apparatus of Schulthess (Fig. 319).—By means of this appliance the contour of the patient's trunk in any desired plane can be reproduced. Consequently, it records not only lateral deviation, but rotation and changes in the antero-posterior curves too. The essential parts of the machine are a cast-iron frame in which the patient stands, his feet resting on a shelf the height of which can be suitably adjusted. Steadiness is ensured by means of a pelvic clamp, and a rest for the sternum. The writing apparatus consists of a counter-weighted sliding bridge and a pointer. The pointer is connected with a pencil which records the movements made in tracing out any given outline. Thus the line of the spines and the outlines of the scapulæ are marked on the patient, then with the pointer we trace on the patient the outlines thus marked, also the contour of the whole trunk as seen from the back. These details are reproduced on a sheet of paper fixed to a glass panel attached to one side of the cast-iron frame. This panel is in the frontal plane.

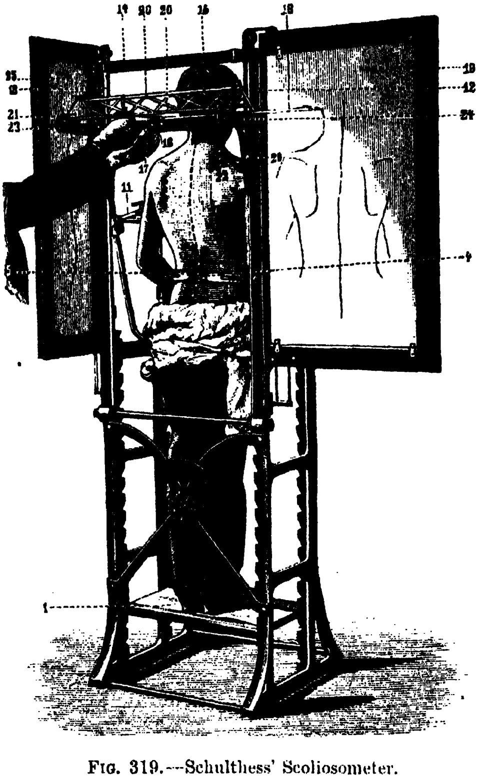

FIG. 319.—Schulthess' Scoliosometer.

On the other side of the frame there is another glass plate and paper, but arranged parallel to a sagittal plane. On tracing the outline of the spine with the pointer, a record is obtained of the kyphosis or lordosis present.

The horizontal contour is recorded on a paper laid on a horizontal shelf, which slides up and down to any desired level on vertical rods forming part of the frame. The shelf can be placed in front of or behind the patient, and the separate records of the front half and back half subsequently joined to afford a complete contour. A glance at the figure of the machine, and at an example of the tracings obtained, will render the principles obvious.

Schulthess says that, except in quite young children and in persons whose skin reflexes are so abnormally active that the passage of the pointer causes reflex movement, the results are accurate and trustworthy. It is so in about 90 per cent of cases.

If at first sight the appliance is somewhat complicated, it must be remembered that it measures lateral deviation, rotation, and alteration of the physiological antero-posterior curves, also the body outline and positions of the scapulæ and iliac crests. It is really, therefore, a great simplifier—since it does what otherwise requires a large number of separate appliances, some of them, such as the rotation-recorders, being none too simple in construction and use.

To sum up, in order to obtain a thorough record of a case of scoliosis we should advise that—

1. A photograph be taken.
2. The actual contours recorded by Schulthess' apparatus.
3. A skiagram, to ascertain the condition, anatomical and otherwise, of the bones, be obtained.

It is impossible, in the space at our disposal, to deal further with the interesting subject of scoliosometry. How thoroughly it has been worked at will be appreciated from the fact that Young in his *Orthopedic Surgery* has made a list of no fewer than sixty-eight appliances of various forms (Young, *Orthopedic Surgery*, p. 563). Schulthess mentions fifty-four different apparatus in Joachimstal's *Handb. orth. Chir.* Lief. iii. pp. 572, 573.

Symptoms and Course

In addition to the curvature of the spine and the general effect on the outlines and structure of the trunk, subjective symptoms are noticed by the patient, namely, pain, and disturbances of circulation and digestion, leading to general malaise and ultimately to impaired health. We may discuss these under four headings, namely, the incipient period, the stages of deformity, arrest, and improvement.

The Incipient Period.—Very often the early stage of the affection is overlooked and does not come under the notice of the surgeon. Children do not complain, and as the back is seldom examined between the ages of five and ten years, very little attention is paid to slight elevation of one shoulder or prominence of one hip; and, if noted, such signs are thought to be of no moment.

In the scoliosis of adolescence a lowering or impairment of the general health is noted at the time of puberty, and the patient is often weary, lolls about, and is unable to bear any prolonged exertion.

The Stage of Development.—In cases where the general health is good, and very often in children, there is little or no pain; but in weakly girls, with scoliosis developing at the time of puberty, pain is often present, though the degree varies considerably. There may be slight aching in the lumbar region, or it may be so severe as to incapacitate the patient altogether.

In a few instances, cases presenting some difficulty in diagnosis have come before the author's notice, where with asymmetry there has been much pain localised to the spine, and some rigidity of muscles. But as a rule it will be found that the movements of the bones are free, though rigidity of muscles and pain may lead the careful observer to suspect that he may be dealing with a case of incipient Pott's disease. The method of treating these cases is to correct the asymmetry, to prescribe rest, and to see the patient on several occasions until the diagnosis can be cleared up.

We also meet with a distinct class of cases, namely, the hysterical girl whose existence is dominated by the idea that she has spinal disease, an idea which may have arisen from an opinion expressed incautiously in her hearing to the effect that she has "back trouble." Localised patches of hyperæsthesia will be noted, together with neuralgic pains in the chest and flanks. Sometimes distinct tenderness on pressure over the spinous processes is found; but this is merely, if it exists with pure scoliosis, an evidence of nervous depression. Hysterical paraplegia or hemianæsthesia may be present.

With severe deformity both local and general pain may exist. The local pain is as a rule on the side of the convexity, and in a dorsal curve will be found a little below the angle of the scapula, and in the lumbar region near the transverse processes.

The causes of pain are:—

1. Prolonged torsion of the muscles and ligaments on the convex side of the curve.
2. Alterations in the shape of the thorax and displacement of the viscera.
3. Pressure of the 12th rib on the lumbar nerves.
   The ribs on the concave side may cause much compression of the tissues of the flank; they may override and rub against the iliac crest; or the ends of the lower ribs may be embedded in the iliac fossa.
4. In advanced cases the nerve-roots are pressed upon, and give

rise to persistent neuralgic pain, especially in congenital cases.

5. Pain finally arises from a general hyperæsthetic condition due to low vitality. Such cases frequently become neurasthenic.

Patients with rapidly increasing total curves are very subject to general pain, probably owing to the inability of the affected structures to adapt themselves quickly to the altered position of the parts. The worst cases of *local* pain occur in the most rigid forms of spinal curvature of many years' duration, which are slowly increasing.

The displacement symptoms are very marked, and in the first edition of this work a case is given of intractable scoliosis, right dorsal and left lumbar, with displacement of the heart downwards, so that the apex was two and a half inches below and outside the nipple; the liver also was depressed two inches below the ribs.

We have already mentioned these visceral displacements, by which the lives of many patients are rendered miserable by feeble digestion, impaired circulation, and limited powers of respiration.[1] Still, it must not be inferred that all cases present so much functional disturbance as we have indicated. Many of them are fairly robust and hearty, and their general health may be described as good.

The ages at which increase of scoliosis occurs are in early childhood; from about ten to under twenty years; from twenty-five to forty years, and in old age. But an examination of a large number of untreated cases justifies the opinion that spontaneous arrest may take place in a considerable proportion, probably of the slighter cases. Yet no one should trust to the possibility of such an event occurring.

In women scoliosis often becomes worse if pregnancy supervene.

When the decadent changes of advancing years set in, a scoliosis which has been quiescent for thirty or more years may increase, and cases have been recorded in which such an increase has taken place as late as the sixtieth year.

The Stage of Arrest.—This may be reached spontaneously or as the result of treatment. It may occur at any stage of the deformity. There are some people of middle age going about without much apparent deformity, in whom an examination of the back

[1] Adams, *Spinal Curvature*, p. 171, mentions the case of a lady aged twenty-three, who suffered from severe and periodical attacks of vomiting, but was much relieved by an efficient support.

shows that they have suffered from a small amount of distortion which has evidently undergone spontaneous arrest. This event also occurs in extreme cases, because bony ankylosis takes place, with ossification of the ligaments, the parts having settled down to the fullest possible extent.

When in the Slighter Class of Cases may Natural Arrest be Expected ?—Total scoliosis generally becomes steadily worse unless treated, still there is a fair chance of a spontaneous arrest and even of cure. If several small curves are present the condition is favourable to spontaneous arrest on account of greater facilities for compensation. An earlier arrest may be expected in a case of double curvature when the curves are equal, than if they are unequal.

An important factor in limiting spinal curvature is a high level of general health, with increase of muscular power. Many adolescents, when they cease to lead a town life and live at the seaside, often improve remarkably. The nearer the patient is to the age of completion of growth, when scoliosis commences, the more likely is it to be arrested before it has become extreme.

We are not referring here to exceptional cases such as scoliosis in repeatedly pregnant women, osteomalacia, and senile kyphoscoliosis.

Spontaneous improvement may be observed in cases due to bad posture on removal of the cause, provided no serious structural change has taken place, and in symptomatic cases such as ischias scoliotica; but anything like a spontaneous cure of a scoliosis with definite osseous changes is most improbable. A restoration, more or less, of apparent symmetry may take place by the development of compensatory contra-curves. The progress of such changes can be registered by the methods we have already dealt with under scoliosometry.

CLINICAL TYPES

We now refer more fully to this aspect of the deformity.

Total Scoliosis

By "total" scoliosis (Fig. 293) is meant that clinical type in which the whole length of the spinal column is involved in one long, usually gentle curve—the maximum lateral displacement being in the middle of the curve, or just below it; that is, at the

lower dorsal vertebræ. As a rule the convexity of the curve is directed to the left (Fig. 293).

The maintenance of the head in the erect position appears, from a mechanical point of view, to require compensatory curves of sufficient magnitude to balance any primary curve present. And from this standpoint "total" scoliosis might appear to be an impossibility. The inspection of museum specimens tells us, however, at once that the mechanical considerations governing the behaviour of elastic rods must not be pushed too far. Very marked simple bends may and do exist with the slightest compensatory curves or none at all. In total scoliosis the displacement laterally is usually slight, and by the time the curve has reached the upper cervical region it has usually tailed off imperceptibly into the normal outline, and little or no compensation is needed. The same remark applies to the lumbo-sacral junction. In one sub-type the whole body from head to foot is involved in one simple C-curve. Mr. Barwell has described this condition under the designation of "amesial pelvis." Of course, here the presence of compensatory curves is out of question. Clinically, then, cases of "total" scoliosis do exist, and pathologically the conception is justified.

Total scoliosis is regarded, and justly so, as a type met with especially in early life. A large number of left total curves are seen during the systematic examination of school children. These are "postural" curves and may—

(*a*) Be cured spontaneously.

(*b*) Develop into true "total" scoliosis, with definite structural change.

(*c*) Be transformed into the S-shaped curve.

A "functional"[1] curve we regard as the same thing as an "occupation" curve. In that sense, viz., adaptive structural changes occur in the spine as the result of continual use in a certain position in masons, labourers, joiners, shoemakers, and school children, so that a "functional" curve is of necessity "postural." However, if no structural change is present no scoliosis is present. In other words, many postural curves do run on into scoliosis, and the postural condition becomes structurally stereotyped. Kirmisson describes such a case, that of a girl æt. 14 years, whose occupation, consisting in putting into motion with her right hand a wheel placed below

[1] The author does not use the term "functional" here in the same sense as in medicine, that is to say, as indicative of a morbid condition in which no structural alteration can be demonstrated.

her, developed a severe total scoliosis, with marked left convex-sided rotation. As a rule the curvature in total scoliosis is not severe, the deviation from the middle line rarely exceeding 1 or $1\frac{1}{2}$ inches.

We have already referred to the question of the so-called concave or paradoxical rotation, and it is especially in connection with "total" scoliosis that this discussion has arisen. The Schulthess school say that it is present in 27·5 per cent of the cases (Steiner); and Lovett, biased by theoretical considerations, and taking definite convex rotation as the criterion of structural change, thus classifies scoliosis :—

I. Functional scoliosis = total scoliosis; postural scoliosis. The type of rotation, concave. No structural change.
II. Transitional curves.
III. Structural curves. Rotation convex. Lumbar, dorsal, dorso-lumbar, cervico-dorsal, and compound structural.

And he does not even mention a total structural with convex rotation. We do not think Lovett's classification can be accepted for a moment. Hess has shown that 70 per cent of the total scolioses observed by him remained as such, and Schulthess, who may be regarded as the defender of the concave rotation type, accepts Steiner's figures of 27·5 per cent as being the outside occurrence of the concave rotation cases. That is to say, "total" scoliosis is certainly not always a temporary phase, and concave rotation, even if we accept it, is exceptional; whereas, according to Lovett, total scoliosis should be temporary and characterised by concave rotation. If we put it in other words, Schulthess acknowledges that three out of four cases of total scoliosis show definite convex rotation—and convex rotation Lovett lays down as the sign of structural change.

But granting that, clinically, occasional cases of *apparent* concave or paradoxical rotation are met with in scoliosis, we have already given reasons for accepting the evidence afforded by rotation rather than that by the spinous processes, and if the right ribs are prominent posteriorly we conclude that the corresponding vertebræ are rotated to the right, and the column of the bodies curved to the right, even if the line of the spinous processes shows a curve to the left.

The fact probably is that some 30 per cent of total scoliosis transform into other types—chiefly the right dorsal, left lumbar S-curve—and the *apparent* concave rotation is an evidence that what looks like, viewing the spines only, a simple curve, is really a compound one; the apparent concave rotation being in reality the regular convex rotation of the compensatory upper curve. Thus Reiner and Werndorff have shown skiagraphically that what appeared to be a typical "total" scoliosis with concave rotation, was in reality a scoliosis triplex with no concave rotation at all.[1] Lorenz[2] brings forward a very telling point against the

[1] *Zeitschr. f. orth. Chir.* xix. p. 203. [2] *Ibid.* p. 201.

acceptance of concave torsion. He shows that the signs of concave torsion are never (we should prefer the word "rarely") noted opposite the summit of the curve, as they should be if the condition existed, but are far removed from this level. He says: "As a fact there is no concave torsion, since this never corresponds to the summit of the total curve, but belongs to the system of the adjacent overlying and clinically latent curve, and is relatively to this regular convex torsion." We hold then that concave torsion in scoliosis does not exist, concave rotation may be present in certain positions of the normal spine, apparent concave rotation may be met with in scoliosis, chiefly in total scoliosis, but it is only apparent.

My friend and colleague, Mr. F. R. Fisher, long ago pointed out that in long C-curves convex-sided rotation might be absent, and spoke of such cases as lateral deviation without rotation. The observation still remains good although the interpretation needs modifying.

The clinical characteristics seen in left total scoliosis are as follows:—

(1) The spines present one long simple C-curve, convex to the left.

(2) The left shoulder is usually raised.

(3) The space between the hanging arm and trunk is larger on the right than on the left.

(4) The right loin and lower ribs are depressed, the left is prominent. That is, signs of rotation (convex rotation) may be marked.

(5) In the "paradoxical" cases, for example a left apparent total scoliosis, the right ribs may be prominent, and the shoulder girdle rotated in the same sense; that is, the right shoulder is posteriorly displaced.

In boys the number of cases of total scoliosis increases steadily with age; in girls a decrease is noted after the twelfth year, although the lumbar type becomes more prominent.

The Lumbar Type

Here the curvature is restricted almost entirely to the lumbar region, the summit of the curve being mostly opposite the second lumbar vertebra. Two sub-types are met with.

1. The spine, deviated to one side below, fails to regain above the mesial line of the body. In these "overhanging"

cases the upper trunk overhangs the lateral mass of the pelvis on the convex side of the curve, and the sagittal median plane of the head does not correspond with the mid-line of the pelvis (Fig. 320). According to Schulthess, this condition was met with in 28 of 89 cases. The deviation of the spine may commence at the lumbo-sacral junction, in which case marked deformity of the lumbo-sacral disc, and eventually of the fifth lumbar and first sacral vertebræ may result; or the deviation may begin from the very tip of the sacrum—the line of the sacral spines being implicated in the curve, in which case the designation lumbo-sacral is more appropriate.

2. In the other sub-type the spine returns higher up to the mid-line, and the upper trunk and head are not laterally displaced (Fig. 321).

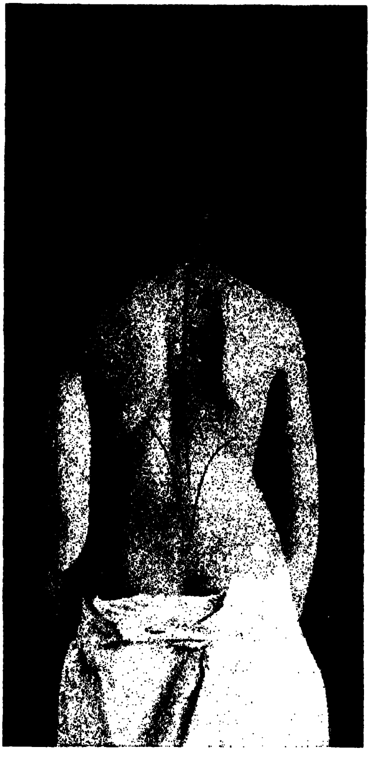

FIG. 320.—Left Lumbar Scoliosis, not returning to the median line, Overhanging Lumbar type. The lines indicate the median plane, and the flexibility to each side (Lovett).

Lumbar scoliosis as a whole is about as often right as left convex, but the "overhanging" type, especially with a sharp bend at the lumbo-sacral junction, is preponderatingly left convex. Lumbar curves, especially the left convex, show a marked tendency to become complicated by a compensatory and contra-dorsal curve.

Females are more often the subjects of lumbar scoliosis than males, the proportion being two to one. Most cases are met with between the twelfth and fifteenth years of age.

The curve is often short and abrupt, and is particularly obstinate to treat. One reason is the absence of ribs, by means of which indirect pressure could be exercised on this region.

In the static form of scoliosis, associated with a short limb, the spinal curve is essentially lumbar or lumbo-sacral. We shall

refer to this again under ætiological varieties, and the above remarks refer to the so-called idiopathic form.

Clinically, the most striking feature in lumbar scoliosis is the prominence of the hip on the concave side of the curve. Thus, in a left convex case the trunk is shifted to the left,

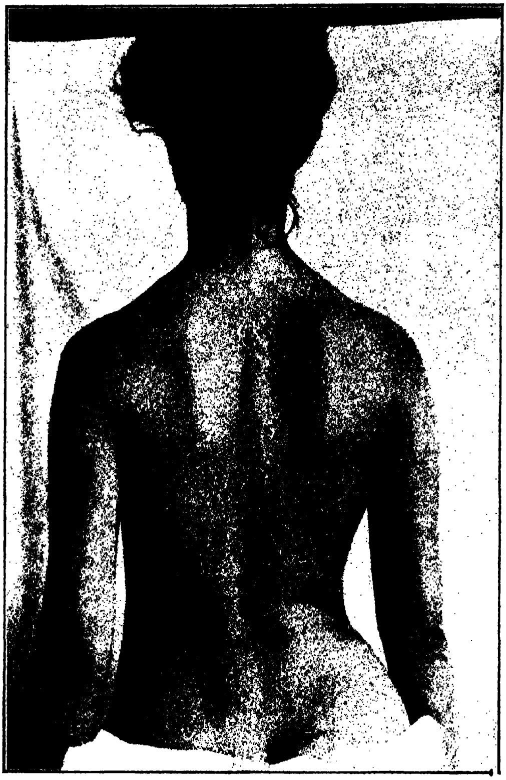

FIG. 321.—Left Lumbar Scoliosis. The Spine returns to the Median Plane above: Non-Overhanging Type (Schulthess).

with the result that the right ilium is, relatively to the contour of the loin, markedly in evidence. The left loin is full and prominent, and more or less cloaks the outline of the hip on that side; while the right loin is depressed, and the redundant skin is thrown into transverse or slightly oblique folds. The fulness of the convex-sided loin and shrinkage on the concave side are due in part to the lateral displacement, and in part to

the rotation of the transverse processes and bodies to the convex side of the curve. Since lumbar rotation is less marked in its external effect than dorsal, the rotation of the bodies in lumbar curves is often under-estimated, and the nature of the deformity can only be appreciated by experience and the knowledge gained from pathological specimens (Figs. 304, 305).

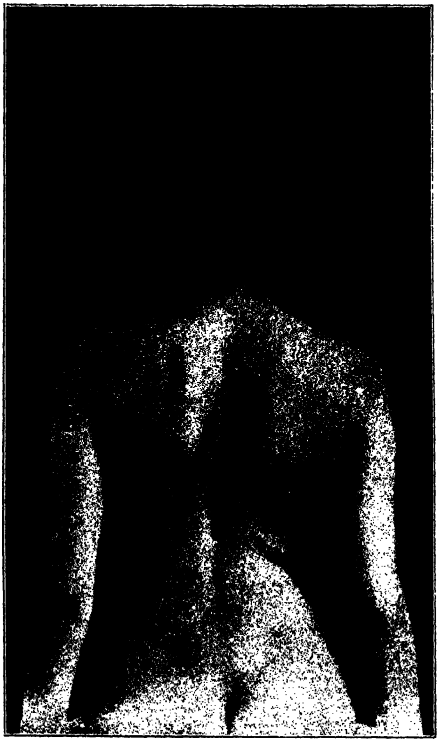

FIG. 322.—Scoliosis, Right Dorsal, Left Lumbar Type, with Lordosis, in a girl aged 16 years (Schulthess).

In left lumbar curves, lateral bending is more free to the right than to the left, and *vice versa* for right lumbar curves.

The lumbar type according to Schulthess embraces about 11·7 per cent of all cases.

DORSO-LUMBAR TYPE

This is more frequently met with than the preceding. Schulthess in 1140 cases of scoliosis found it present in 20 per cent. The

summit of the curve, especially in the left convex form, is situated at the junction of the twelfth dorsal and first lumbar vertebræ, and a larger number of vertebræ are affected than in the preceding type, so that it is apt to be mistaken for total scoliosis. It is

FIG. 323.—Rachitic Scoliosis, Left Dorsal, Right Lumbar, in a man, aged 58 years (Schulthess).

very like the lumbar form clinically, but the sharp sacro-lumbar bend is absent.

Two types are met with—(1) That in which the curve is slight and lordosis is present (Fig. 322), and (2) A severer form, either rachitic or rarely paralytic, in which kyphosis is marked (Fig. 323).

The formation of compensatory curves is slight. The primary

curve is usually left convex (four to one). Rotation is convex-sided at the summit of the curve, and may be apparently concave-sided at the shoulder girdle, also the concave-sided shoulder is usually depressed. It is found nine times as frequently in females as in males.

FIG. 324.—Scoliosis, Right Dorsal, with marked Kyphosis (Schulthess).

SIMPLE PRIMARY DORSAL TYPE

Here we meet with a simple curve involving the dorsal region and without any compensatory curve above or below. The point of greatest curvature is from the sixth to the eighth dorsal in the majority of cases. It is more frequent than the lumbar type, and next in frequency to the lumbo-dorsal type, being present in 19 per cent of cases according to Schulthess.[1]

Two forms of it have been described: (*a*) The simple slight curve; (*b*) The simple severe curve.

The simple severe curve (Fig. 324) is accompanied by a great amount of rotation and marked kyphosis. In slight cases, however, there may be lordosis, giving rise to the flat-back type, but, as a rule, if lordosis is present the curve is no longer *simple*. In the severe form of scoliosis rotation reaches its extreme expression, clinically. It is always convex-sided in character, and the rotatory deviation of the bodies, combined with the lessening in height of the trunk from above downwards, leads to alterations in the position of the viscera, and to pressure effects, such as displacement of the heart, with subsequent dilatation and right-sided

[1] Joachimstal's *Handb.* 4. Lieferung, p. 854.

hypertrophy, and pulmonary collapse. A liability to pneumonia and pleurisy, and symptoms due to pressure on the abdominal viscera, are also noticeable. Such patients are said to be very prone to phthisis. Schulthess states that scoliotics with this type of curve die between forty and fifty years of age from cardiac dilatation and dropsy.

A point which has not been sufficiently studied is the association of tachycardia with dorsal, and especially cervico-dorsal cases. It is probably the cardiac response to injurious pressure effects, to be followed later by hypertrophy and dilatation.

When the curve is single, it is as often to the right as to the left, but single dorsal curves are much less frequent than dorsal curves in combination with other forms. The right dorsal is, in reality, much more frequent than the left dorsal curve, but shows a much greater tendency to the formation of a compensatory lumbar curve, so that in the end simple right dorsal is only about as frequent as simple left.

Changes in the Outline and Shape of the Trunk.—When viewed from behind, if the case is one of right dorsal curvature of marked severity, the right side of the thorax is prominent. The right shoulder is raised, and often carried forwards. The curvature of the right clavicle is increased, and the right arm hangs away from the trunk, making a greater angle with it than the left. The right flank is flattened, and the right ribs are more sloping, reaching down towards the crest of the ilium, "obliterating the natural waist indentation." The compression of the soft parts, thus arising, frequently causes persistent pain. The scapula on the right side is raised and prominent, and is oblique or nearly horizontal. The angles of the ribs may become acute, and render the deformity caused by the prominence more marked than ever (cf. Fig. 324). The prominence of the ribs is best seen when the patient is directed to cross the arms on the chest and bend forward. The left shoulder droops and is carried backward. The left side of the chest posteriorly is flattened, or even concave, and the scapula is buried. The angles of the left ribs are flattened, and the ribs themselves are less obliquely placed than normal. Very frequently a fold of skin is seen to run upward and inward from just above the crest of the left ilium, obliquely to the concavity of the dorsal curve.

In the spine, the apices of the spinous processes are twisted to the left, so that the right transverse processes come into prominence

and occupy somewhat the line formerly taken by the spinous processes.

The effects on the thorax viewed from the front are equally remarkable. The left side of the thorax is more prominent than the right, and the mammæ correspond. The lower end of the sternum is generally displaced towards the convexity of the curve. The greatest diameter of the thorax is no longer the transverse, but the right oblique.

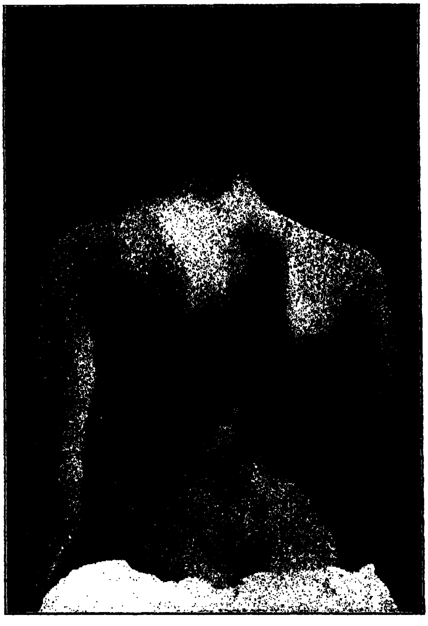

FIG. 325.—Cervico-Dorsal Scoliosis in a girl, aged 16 years (Schulthess).

CERVICO-DORSAL TYPE

This is not very common, occurring in less than 4 per cent of cases. The curve is more often right than left, and the lateral deviation is greatest at the third or fourth dorsal vertebra.

A definite clinical picture is presented, characterised by a short, sharp curve, and overhanging or lateral displacement, with regard to the mid-sacral line, of the upper part of the trunk (Fig. 326). Kyphosis is well marked. The head is pushed forward, and bent toward the concave side of the curve; and to bring the head

erect again the whole upper trunk is thrown over to the convex side. This is the cause of the sometimes enormous and characteristic "overhanging." There is, of course, no room for an upper compensatory curve. The scapula on the convex side is very high and prominent, and the anterior border of the

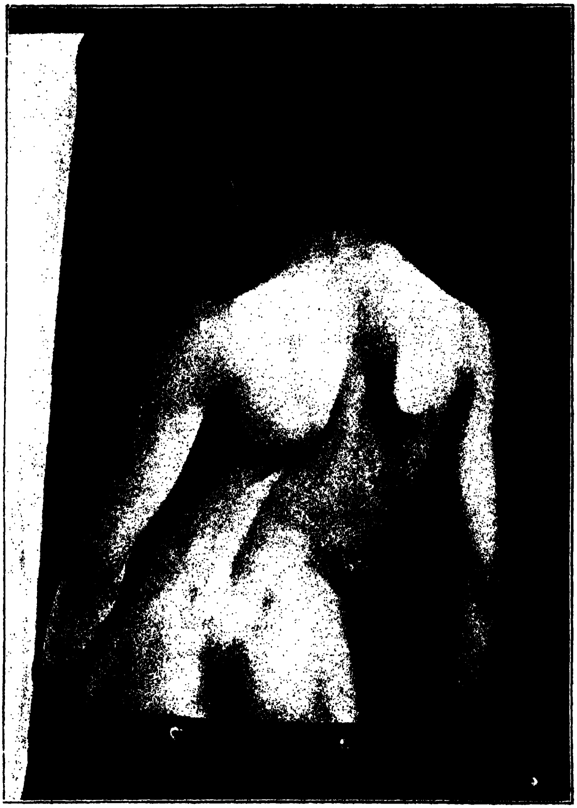

FIG. 326.—Severe Rickety Cervico-Dorsal Scoliosis in a boy, aged 15 years (Schulthess).

trapezius stretches straight across from the head to the shoulder. The vertebral border of the scapula, which is depressed on the concave side, may actually override the spinous processes. The neck is obviously shortened. The arm of the convex side hangs farther from the side than the other. Rotation is very evident, and causes the upper ribs to be so prominent that the patient appears to be hump-backed.

Schulthess says that this type is mostly rachitic in origin,

and with this the author agrees. However, two very severe cases seen by him were associated, the one with very old-standing spasmodic torticollis, and the other came on at the age of fifteen years in a non-rickety lad, whose sister was suffering from slight scoliosis.

Compensated Dorsal Curves

These are also called complex dorsal or double scoliosis, and by Lovett "compound structural curves." This type is much the most frequent. It includes some 30 per cent of all cases, and the bulk are right dorsal and left lumbar in character. W. Adams found this to be so in 470 of 569 cases. The author holds this form to be due to the preponderating use of the right hand, especially in children of the school age, in whom the deformity is aggravated by the left lumbar curve, induced by the vicious positions often adopted in learning to write the oblique or Italian hand.

The usual combination is right dorsal and left lumbar, but variations will be met with, and the most predominant curve will determine the clinical features. The question as to which is the primary, the dorsal or lumbar, is not always easy of solution. Fortunately it is a matter of academic rather than of practical importance. The suggestion that the more fixed curve is the primary is not very pertinent, since it often happens that both are equally fixed, and in many cases both curves appear simultaneously. Those who regard right-handedness as an important factor in ætiology are inclined to favour primary dorsal. And, as we have seen, cases of left "total" scoliosis undergo a transition stage, and become right dorsal and left lumbar. We hold, therefore, that while primary lumbar is the rule in static or short-legged cases, in the ordinary habitual form the dorsal curve is the primary.[1] The summit of the dorsal curves falls opposite the sixth to the eighth dorsal vertebræ with a frequency quite extraordinary.[2] As the

[1] Ludwig and John Shaw believed that scoliosis always starts in the lumbar region. W. Meyer, in 336 school-girls, found it began in the lumbar region, and B. Schmidt agrees with him. Drachmann and Lorenz hold that primary dorsal and primary lumbar are about equal in frequency. Kirmisson thinks that the bulk of cases are primary dorsal. Heine, Adams, and Eulenburg say that primary dorsal curves form 81, 84, and 92·7 per cent of the cases respectively.

[2] See statistics as to the exact position of the summit of the bend in this and the other forms. The reader is referred to an elaborate article by E. Hess, in the *Zeitschr. f. orth. Chir.* Bd. xiv. Heft 2.

curvature increases, its summit is found to be shifting to a lower point.[1]

A point of diagnostic importance, as the author has shown, is that when curves nearly equal are present, at the point where

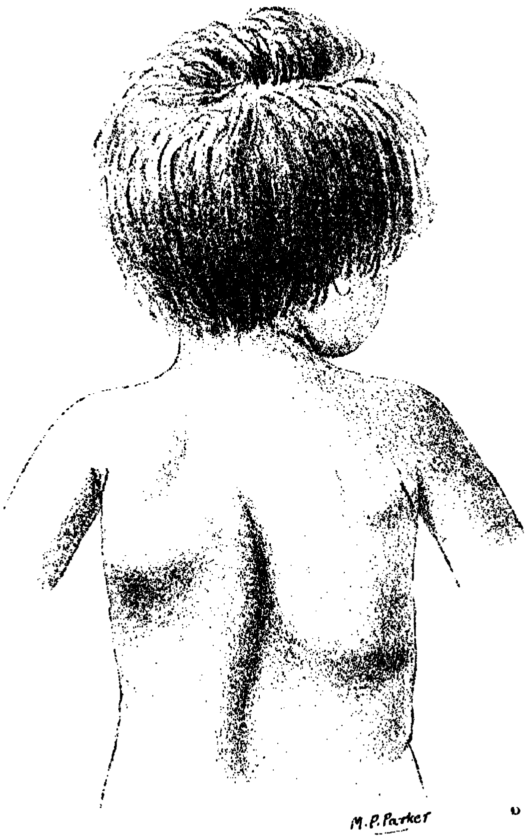

FIG. 327.—Scoliosis of the Double Type, or the Compensated Dorsal Form, in a child, aged 2 years, and due to Rickets.

they meet a projection of the spinous processes may sometimes be seen.

Three sub-types of the compensated dorsal form should be

[1] The migration downwards of the summit of the dorsal curve might be deduced as a probability from the analysis of the graphic methods of Schulthess (Joach. *Handb.* 4. Lief. p. 871), but its actual occurrence has been observed in the course of years by Hoffmann (p. 859).

differentiated—the double (Fig. 327), overhanging (Fig. 328), and the triple curve. The last is represented in Fig. 295, p. 407. The double and overhanging sub-types together form the bulk of the adult cases, and are the classical scoliosis of the general text-books on Surgery. So many grades and points of difference are met with in compound structural curves that it is impossible to deal with them all. Some of the cases are complex from the first, and others arise from simple forms. Those cases, which are untreated, more frequently remain nearly simple than others. But if one curve becomes extreme in degree or great in its extent, the compensatory curves[1] may be overpowered or altered in character. However, it is certain that the less the resistance of the spine, the greater is the tendency to multiple curves, as is seen in osteomalacia.

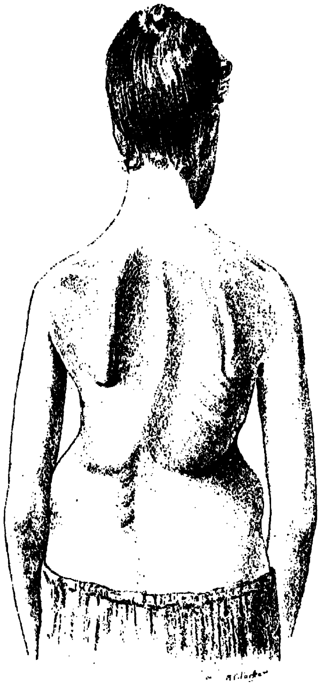

FIG. 328.—Scoliosis, Dorso-Lumbar and Overhanging Type, in a girl, aged 14 years. There is also a considerable degree of Dorsal Kyphosis.

The clinical[2] picture in a spine with a dorsal curve convex to the right and a lumbar curve convex to the left is as follows:—The right shoulder is higher than the left; the right scapula is raised, and is more distant from the median line. The right hip is more prominent than the left, and the space between the pendent arm and outline of body (brachio-thoracic angle, or "Taillendreieck" of Lorenz) is larger on the right side than on the left side. The

[1] Thus, probably in an italic *f* curve, the dorsal bend may progress and overpower the lumbar. Then the case eventually becomes a simple severe dorsal with a marked compensatory bend at the lumbo-sacral junction.

[2] It is impossible to give one all-embracing clinical picture. Thus, in a slight right dorsal and left lumbar curve, the curves being about equal, the general symmetry of the body is but little impaired, and the head is median over the pelvis. In the severer "overhanging" types—the mechanism of the lateral displacement may be that described in the cervico-dorsal type, if the dorsal curve is marked and high; or as in

right hip looks prominent, because the soft parts in the right loin are deflected to the left, following the curved lumbar vertebræ. The thorax experiences the same changes as in the simple dorsal type; and in fact the appearances, except for a modification in the position of the ribs in the double curve, are similar to those resulting from the displacement of the lower part of the trunk to the left side. Whether it is the right or the left hip which is more prominent depends upon the position of the trunk.

In triple curves the rotation is convex-sided throughout, the thorax being twisted to the left above and to the right below. Rotation, as in other compensated cases, is not extreme.

ÆTIOLOGY—ÆTIOLOGICAL CLASSIFICATION—ÆTIOLOGICAL FORMS

The ultimate causation of scoliosis is spinal insufficiency or lack of resistance. The over-weighted spine "gives" and "bends." The load need not be abnormally great, yet if the supporting column is not sufficiently resistant it is relatively overloaded. In the widest possible terms the deformity is due to a want of relationship between the weight to be borne and the weight-bearing mechanism, which of course includes the muscles and ligaments as well as the bones. This view has been summarised by Schanz[1] in the formula

$$B > T = D$$

where B represents the load, T the carrying power, and D the deformity.

At first sight this statement appears so obvious as to be almost superfluous, and probably it would have been but for the influence of J. Wolff's teaching, according to which scoliosis might be functional, using "functional" in the widest sense. It cannot be denied that the occurrence of occupation scoliosis does lend undoubted support to Wolff's views up to a certain point. For the structural

the lumbar type, if the lumbar compensatory bend is sharp. And in either case the clinical picture approximates to the cervico-dorsal and lumbar type respectively. Then the description of the thorax in the usual double curve will need modification to apply to the case of a triple curve. Further, the "flat back," or lordotic type, looks very different from the kyphotic. And the severe kyphotic shades off into the severe simple dorsal kypho-scoliosis, where rotation may be, and usually is, extreme. Once more we must emphasise the necessity of carefully noting rotation signs. In the case of a multiple curve especially, these are the guides to the actual condition of the spine.

[1] *Zeitschr. f. orth. Chir.* Bd. xiv. Hefte 3 and 4.

conditions in such cases appear to be changed and adapted in accordance with the altered functional requirements. But this view can only hold good of normally resistant bone, in which case severe deformity does not arise. It is impossible to believe that the scoliotic deformities seen in, *e.g.*, osteomalacia are functionally adaptive; and if we once admit the principle of mere mechanical lack of resistance, it becomes a moot point in any given case where this ends and functional adaptation begins. Keetley[1] put the case very neatly. "This teaching of Wolff's has been brought to a *reductio ad absurdum* by one of his disciples, who writes that the torsion of the scoliotic thorax is the expression of functional change in the thorax, and that it is physiological, and therefore the best form which nature can give the thorax with altered statical conditions. Korteweg of Amsterdam remarks that it is a pity that persons who suffer from this 'physiological' disease are so ill content with it."

To return to the theory of relative insufficiency:—The weight to be borne may be increased by fat, heavy clothing, and carrying burdens. The effect of the weight may also be intensified by the prolonged assumption of one position, as in certain callings, by the demands of school life, and the relative immobility incident to advancing years. The effect of the weight is enhanced by eccentric loading, as in bad posture in sitting, writing, and in static cases. Many of the congenital cases are closely associated with a tilted pelvis. The resistance of the spinal mechanism may be diminished by the occurrence of bony softening, as in rickets, osteomalacia; or by atrophic changes, as in old age; or by prolonged inactivity from severe illnesses. The effect of paralysis or muscular weakness is obvious.[2]

Granting, then, that relative insufficiency is the ultimate causation, this may be brought about in various ways, the proximate causes giving rise to different ætiological forms. There are many ætiological forms, and several of them are numerically unimportant, still, as they throw much light on the ætiological problem, we cannot afford to neglect them, even at the risk of appearing somewhat pedantic. We shall therefore deal with a somewhat extended causal classification, bearing in mind always that the great bulk of the cases come under three headings—the idiopathic or constitutional, effects of

[1] *Orth. Surg.* p. 7.

[2] For a fuller exposition of this train of thought see Schanz, *Zeitschr. f. orth. Chir.* Bd. xvii.

occupation, and the rachitic; other causes are responsible for a small percentage of cases.

Ætiological Classification of Scoliosis

It is very difficult to make a satisfactory classification which will embrace all the causes of deviation of the vertebral column, and there is always a danger of such a classification becoming a mere list of immediate and remote possibilities. Still it is hoped that the following table is a fairly complete one, and not too minute:—

A. **Congenital Scoliosis.**

1. Curvature arising from congenital anomaly of the spine, such as portions of supernumerary vertebræ.

2. Curvature arising from some congenital extra-spinal anomaly, such as deficiency of ribs.

3. Due to intra-uterine malposition.

B. **Acquired Scoliosis.**

1. Constitutional or idiopathic, due to general insufficiency[1] of the spine.

2. Due to processes of bony softening.
   - i. Rickets.
   - ii. A few cases traceable to osteomalacia, osteomyelitis, gumma, tubercle, injury, arthritis deformans, new growths.

3. Occupation scoliosis.

4. Static scoliosis from pelvic obliquity, which is in turn due to a large number of causes ranging from coxitis to unilateral flat foot.

5. An asymmetrical position of the trunk, from diverse causes. We may mention torticollis, unequal vision or hearing, loss of one arm.

6. Associated with certain nerve conditions.
   - i. Infantile paralysis.
   - ii. A few cases due to hysteria, sciatica, locomotor ataxy, syringomyelia, Friedreich's disease.

7. Due to malformations or diseases of the soft parts. Pleurisy, empyema, phthisis, heart disease, skin cicatrices from burns, and

[1] For the meaning of insufficiency see pp. 458, 459.

PLATE XXIV.

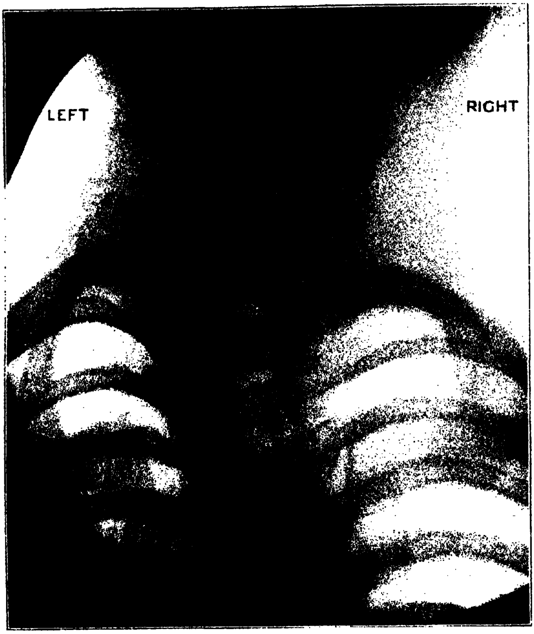

FIG. 1.

Radiogram of a Case of Congenital Cervico-Dorsal Scoliosis and Left Cervical Rib.

FIG. 2.

Radiogram of the Dorsal Spine of the same case as in Fig. 1.

To face page 461.

following the kyphosis due to nasal stenosis, adenoids, and enlarged tonsils.

A. Scoliosis of Congenital Origin

Congenital anomalies of the spine are of very frequent occurrence. We do not refer especially to the cruder malformations such as extensive spina bifida,[1] but rather to the type of anomaly coming under the designation "numerical variation." This subject has been studied, from the anatomical standpoint, especially by Bianchi,[2] Steinbach,[3] Bardeen,[4] Dwight,[5] and Fischel.[6] Fischel has shown that "numerical variation" is met with in 22 per cent of unselected spines.[7] Now Max Böhm found that in Dwight's collection of 52 spines showing numerical variation, no fewer than 26 were definitely scoliotic, and the type of scoliosis met with was similar to that seen in "idiopathic" cases. Böhm concluded that numerical variation was evidently a causative factor in idiopathic scoliosis, and has confirmed this by demonstrating signs of such anomaly in 29 of 30 clinically idiopathic cases, occurring between the ages of 12 and 17 years. Skiagrams of a number of cases are given in the *Zeitschr. f. orth. Chir.* vol. xix., 1907. Skiagraphy yields here more information than might be anticipated at first sight. This is partly because variations of the ribs and vertebræ must be taken together, a vertebra and its attached ribs forming a spinal segment. Also changes in the 5th lumbar vertebra are readily distinguishable. The anomalies to be looked for are a reduction or increase of the supra-sacral vertebræ, that is variation towards the cranium or coccyx. The former preponderates in females, the latter in males; and so too does the shifting of the thoracic cage upwards or downwards. Thus, normally the 8th vertebra is the first rib-bearer, the 19th the last rib-bearer, the 25th the first sacral. In the extreme and typical variation in the cranial direction the 7th vertebra is the first rib-bearer, the 18th the last

[1] Kirmisson: Spina bifida, Spina bifida occulta, association with scoliosis, *Rev. d'orthop.*, Sept. 1907, pp. 508-509, and Plate xxv.

[2] "Sulla frequenza delle anomalie numeriche vertebrali nello scheletro dei normali e degli alienati," *Estr. d. Atti della R. accad. di fisiocrit.*, Siena, 1895, ser. iv. v. 5.

[3] *Die Zahl der Kaudalwirbel beim Menschen*, Diss., Berlin, 1889.

[4] "Variationen der Wirbelsäule," *Anatom. Anzeiger*, Bd. xviii.

[5] "Numerical Variation in the Human Spine," *Anatom. Anzeiger*, 1906, Bd. xxviii. Nos. 1 and 2.

[6] Quoted extensively by Max Böhm.

[7] In connection with the subject of "Congenital Scoliosis," chap. i. sect. i. vol. i. on "Congenital Deformities of the Vertebral Column" should be read.

rib-bearer, and the 24th the first sacral. While in the caudal variety the 9th is the first rib-bearer, the 20th is the last, the 26th the first sacral. Between the extremes every grade may be met with, *e.g.* cervical ribs, rudimentary cervical ribs, a first dorsal rib failing to reach the sternum, last ribs abnormally short, 13 ribs present, 11 dorsal vertebræ, 4 lumbar vertebræ, 6 lumbar vertebræ, and so on. As to the ultimate causation of these varieties, supra-sacral increase may be regarded as atavistic, diminution as

FIG. 329.—Posterior view of a child, aged 2½ years, the subject of Congenital Scoliosis.

FIG. 330.—Anterior view of the child in Fig. 329.

futuristic. But these variations have a great tendency to be asymmetrical, and therein lies the bearing on scoliosis. Thus the 5th lumbar may approximate in character to a sacral vertebra. This would not matter, but if the sacralisation of the 5th lumbar affects one side only, the result is likely to be scoliosis from primary asymmetry, such as exists, with a cervical rib one side only, or with a supernumerary half-vertebra at the dorso-lumbar junction.

It must be acknowledged that Böhm's skiagraphic researches on the idiopathic form strongly support his theory of a congenital origin; but if the condition is congenital, why do not clinical signs arise before the second decennium; and why does the condition

preponderate so markedly in females? Still, without doubt, Böhm's researches must bring congenital scoliosis well into the clinical field. Hitherto the subject has been regarded rather as one of museum interest. Numerical variation in scoliosis was known to be not uncommon. In Figs. 304, 305, we illustrate such a case from the Guy's Hospital Museum, in which six lumbar vertebræ are present. A specimen at the Hunterian Museum, No. 2098, shows six lumbar vertebræ, associated with a well-marked *f*-curve. Peronne described three specimens, from the Berlin Museum, of sacralisation of the last lumbar vertebra, in each case asymmetrical, and giving rise to scoliosis. Schulthess and others figure similar cases (Fig. 331), and on pp. 11 to 15 we have described examples of mal-development collected from the literature of the subject. Apparently the mistake has been made of clinically overlooking congenital scoliosis, unless deformity was obvious at or soon after birth. According to this criterion it must be very rare indeed. Thus Coville examined 1015 infants from a day to three months old, and only met with it once; but as Lüning and Schulthess[1] pointed out, the deformity could not be expected to show itself until the child began to sit and walk. The fact is, probably, that

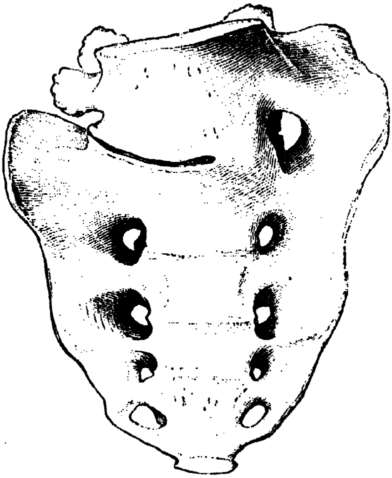

FIG. 331.—Sacralisation of Last Lumbar Vertebra. The body of the latter is wedge-shaped, and on the left side it and the Articular Process are fused with the Lateral Mass of the Sacrum (Disse).

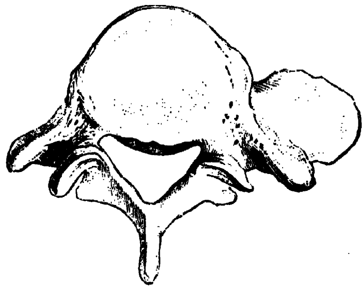

FIG. 332.—Partial Suppression of Lateral Mass of a Vertebra (Disse).

[1] Schulthess states that some 60 to 80 cases of congenital scoliosis have been recorded, and he believed that, bearing in mind the importance of the hereditary factor, many slight cases are overlooked or otherwise described.—*Zeitschr. f. orth. Chir.* Bd. xiv. Hefte 3 and 4.

there are three groups of congenital scoliosis, and they behave differently from a clinical point of view. These are—

i. Congenital scoliosis, due to intra-uterine malposition,[1] according to Hoffa.

ii. Congenital scoliosis associated with numerical variation of the vertebræ.

iii. Congenital scoliosis associated with more or less monstrosity and extra-spinal anomalies.[2]

FIG. 333.—Congenital Scoliosis and Spina-Bifida (Lovett).

Group 1, when it occurs, is certainly rare. Its presence will be obvious at birth. It is a form not associated with bony anomalies. If the child is held up under the arms, with the back towards the observer, the pelvis is seen to be laterally deviated, and there is a general curve of the whole spine. We have met with three examples of this form (cf. Figs. 329, 330).

Group 2 we have already discussed, and clinically, deformity may be absent at birth. It may come out later when the child sits or stands, and according to Böhm the deformity may first show in the second decennium, and the case be considered as idiopathic. The cause of the deformity is the asymmetry of the spinal variation. For example, the twenty-fifth vertebra may be sacral in type on one side, lumbar on the other.

Group 3 exists, but is rare, and of little practical importance,

[1] *Zeitschr. f. orth. Chir.* Bd. vii. p. 1, Hirschberger; Royal Whitman, *Orthopedic Surgery*, 2nd ed. pp. 167-168.

[2] We shall not discuss here scoliosis associated with supernumerary ribs. A simple supernumerary rib is a spinal or rather segmental anomaly. For information on this subject, in addition to the references given to numerical variation, see pp. 20-30, also Krause, "Die angeborene Cervicodorsalskoliose und ihre Beziehungen zur Halsrippe," *Fortschritte auf dem Gebiete der Röntgenstrahlen*, x. 6; Walker, *Über Halsrippen*, Diss., Halle, 1906; v. Rutkowski, *Zeitschr. f. klin. Medizin*, Bd. lx. Hefte 3 and 4;

as the subjects are usually non-viable.[1] The condition is obvious at birth.

We have then in congenital scoliosis two[2] rare groups in which the deformity is clinically present at birth, and one more frequent group in which deformity may be clinically latent at birth, but appears later.

B. Acquired Scoliosis

This group includes by far the greater number of cases.

1. **The Constitutional or Idiopathic Form.**—It is met with chiefly in an early period of the second decennium. Girls are more frequently affected than boys, especially town-bred girls. There is no history nor sign of rickets, and the subjects are usually over-grown rather than stunted. Such causative factors as unilateral paralysis or paresis, oblique pelvis, unequal vision can be distinctly excluded. However, a close study of the possibilities of congenital scoliosis warns us that we must be careful to exclude this cause. The most generally accepted view of the condition is that of general insufficiency of the spine. By this is meant a want of resistance of the bones, ligaments, and muscles, which cannot, it is true, be substantiated by X-rays or confirmed by anatomical examination. The conception of insufficiency is derived from considerations we shall deal with under other ætiological forms. Schulthess believes that there is a want of resistance and an abnormal plasticity of the spine, and that clinically it shows a marked readiness to compressibility. He points out that in these cases not only are the spinal joints relaxed, but also those of the extremities. Hence the association of flat foot and genu valgum. The muscular system is also lax. In order to balance the spine in a healthy individual, something between normal tone and active contraction, capable of being maintained for a long time, is needed, and this something appears to be absent in apathetic, muscularly weak, and often anæmic children and

Helbing, "Beziehungen zwischen Halsrippen und Skoliose," *Zeitschr. f. orth. Chir.* Bd. xii. Hefte 1 and 2, p. 217; Garre, "Über Skoliose bei Halsrippen," *Zeitschr. f. orth. Chir.* Bd. xi. Heft 1. We do include here scoliosis due to defective development of the ribs on one side.

[1] Cf. Ardouin and Kirmisson, "Étude d'un fœtus exomphale," *Rev. d'orthop.*, 1897, p. 104.

[2] The scoliosis associated with Sprengel's shoulder and congenital torticollis is in a sense congenital, but it is symptomatic, and therefore not included here.

adolescents. The rapid growth and the changes of adolescence put a strain on the patient; and the development of the muscular and ligamentous apparatus is outpaced. Experience must decide how much is muscular and how much skeletal. The two are mutually interdependent. Feeble musculature means small bones and *vice versa*; but the condition cannot be entirely ascribed to weak muscles, as Eulenburg thought.

A prominent feature in these cases is the extreme mobility of the spine. Scoliotics of this class are met with chiefly in towns. It is frequently seen in weedy children and convalescents. The clinical type is mostly the right dorsal left lumbar S-curve; and it is not usually severe. Marked severity suggests some other causation, such as rickets or congenital malformation.

Fig. 334.—From a photograph by Rédard, showing the Effect of the Position, in which a child is sometimes held by the nurse, in producing Scoliosis.

2. (*a*) **Rickets.**—The first effect of rickets on the spine is to cause a general, not a local, increase of antero-posterior curvature. Now, unless the deformity is arrested, or the superincumbent weight of the head and upper extremity is taken off the spine, the antero-posterior curve will develop into a lateral curve, and later into an organic scoliosis. This sequence of events is assisted by the usual way in which a nursemaid carries children on her flexed forearm. The forearm is frequently placed at an acute angle with the arm, and the child rests on an inclined plane. If the child be carried on the left forearm his trunk is inclined towards the nurse's chest so that a total scoliosis, convex to the left, is produced (Fig. 334).

Of 5079 consecutive cases seen by the author at the Royal National Orthopaedic Hospital from 1890 to 1907, 28 were marked examples of rickety scoliosis, under the age of $2\frac{1}{2}$ years. Of 1070 surgical cases seen by him at the Evelina Hospital, eight were examples of this affection at the same age. Some of the worst cases of scoliosis met with in adults are traceable to rickets in early life.

If the existence of late rickets is admitted—a perilous concession—this disease may serve to explain the onset of some cases in adolescents which have hitherto been called consti-

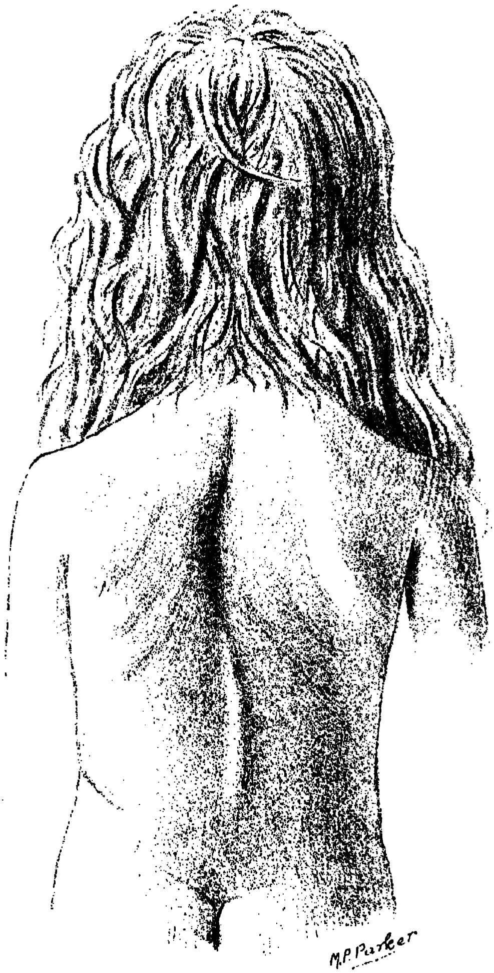

FIG. 335.—Back view of a child, aged 3½ years, suffering from Scoliosis, with Lumbar Kyphosis. From a case seen at the Evelina Hospital for Children.

tutional. However, the evidence and the opinion of observers are very conflicting on this point. Whether rickets is a disease prolonged throughout the whole growing period, with occasional

exacerbations, or late rickets is a distinct entity, is still in dispute.

It is striking to notice in rickety children that, when they sit, they adopt an asymmetrical attitude. Some of the appearances presented by cases of rickety curvature are well shown in Fig. 335. They may be enumerated :—

1. General laxity of the spinal column is present, and with the scoliosis, kyphosis or less frequently lordosis, is associated.

2. In young children, at the ages of two and three years, the deviation is generally to the left, and persists in older children.

3. The primary curve is dorso-lumbar, rather than as in adults dorsal or lumbar.

4. The superior limit of the posteriorly displaced ribs is below the scapula. Therefore that bone does not undergo much displacement.

5. The alteration in the shape of the pelvis is very great subsequently, and may cause considerable difficulty in labour.

The morbid appearance of a spine deformed by rickety scoliosis differs only from that of the scoliosis of adolescents in the unequal growth of the epiphysial plates of the vertebræ, and often in the greater deformity present.

In the florid stage of rickets three types of scoliosis are seen :—

1. The lumbo-dorsal, or marked lumbar kyphotic form.
2. Multiple curves, with severe thoracic deformity.
3. High cervico-dorsal curves.

Of these the first is the most frequent, and the kyphotic element predominates. In Joachimstal's *Handb. der orth. Chir.*, Fig. 770 to 775 are excellent illustrations, showing how severe rickety curvature progresses from childhood to adolescence. Certain it is that many of the most severe cases of lateral curvature in adult life have commenced in infancy and childhood as rickets.

Schulthess[1] lays much stress upon an asymmetry of the skull in scoliosis as indicative of rickets. He says that if the curvature be right-sided the skull is flattened on the left posteriorly and on the right side in front.[2]

It is often asked why should kyphosis, rickety or otherwise, cause scoliosis? Now the remarkable point is that the spine

[1] Joachimstal's *Handbuch*, 4. Lieferung, pp. 940 to 944.

[2] In the case figured by Joachimstal on p. 945 (*op. cit.*) right dorsal, and left lumbar, and cervical curves exist. Asymmetry of the skull is present with shortening of the oblique diameter, from the left side behind to the right side in front.

under the most favourable circumstances should ever remain symmetrical. In the course of this article it is often pointed out that the spine is a very mobile structure, which is simply held in position by the muscles. The static conditions are constantly changing with every breath. This constant change means muscular relief. Unless it took place the muscles would speedily tire, that is to say, any one position long continued means muscular fatigue. Now rickety or other kyphosis is one position long continued—the result is a weakening of the spinal musculature and inability to strive against any tendency to asymmetry.

(*b*) Osteomalacia, osteitis deformans, syphilitic infiltration, and malignant disease are occasionally accompanied by lateral curvature. So too are dislocation of the vertebræ and injury of the epiphysial cartilages. Hereditary syphilis is also mentioned as a cause.

(*c*) Arthritis deformans occasionally is accompanied by lateral deviation,[1] which is preceded by general kyphosis, and this may run on into scoliosis of a severe and intractable character.

In spinal caries, lateral deviation of the spine is sometimes seen, and by the careless is mistaken for scoliosis. The points of distinction have been given on page 408.

3. **Occupation Scolioses.**—We have already indicated that occupation curves may be met with. We do not like the terms "habit" or "habitual" scoliosis. "Habitual" is likely to be taken as signifying the clinical type most frequently encountered, whereas we mean that ætiological form due to the stereotyping of a habitual posture. In this sense "habitual," "postural," or "functional" are the same thing. To prevent misconception we prefer the term "occupation" scolioses.

In occupation scolioses there are many factors concerned, both mental and physical. The mental state frequently seen in young girls is often one of indolence or of shyness, and unless the patient makes an effort to bestir herself, or to overcome her self-consciousness, the effect of any faulty attitude in sitting or standing is likely to be progressive. In fact, those who have had to do with the treatment of scoliosis know how important a factor in the attainment of success is the willing co-operation of the patient.

Another aspect of the mental question is the sense of balance or equilibrium. If this be faulty, no efforts should be spared to cause it to revert to the normal.

On the physical side such patients are often dwellers in towns,

[1] The scoliosis of Bechterew's disease comes under this heading.

anæmic, overworked both in mind and body, and readily sink from sheer fatigue into bad postures. So that many of these cases are really instances of want of resistance to overloading by the trunk and its muscles.

It is well known that certain callings leave their imprint on the physical conformation of the worker. So far as the spine is concerned, changes in the normal physiological curves are more frequently seen than is scoliosis. Examples of this fact are the kyphosis of shoemakers, tailors, and the round shoulders of the too intensive or myopic student. The opposite condition, lordosis, is met with in soldiers and some athletes. And the stereotyping of an

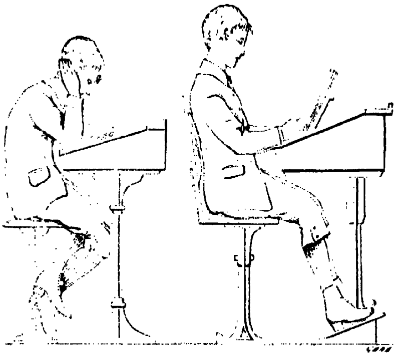

FIG. 336.—Occupation-Scoliosis. Faulty and Correct Positions at School.

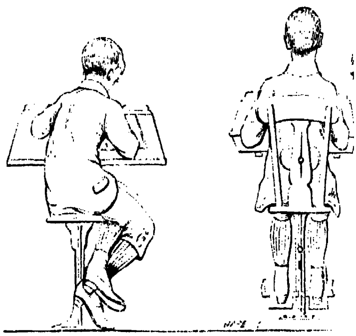

FIG. 337.—Occupation-Scoliosis. Faulty and Correct Positions at School. The effects of twisting the legs on the shape of the back are seen.

asymmetrical attitude may be met with in what Schulthess calls "the pure functional curves."

In the previous edition of this work, p. 121, the author recorded the case of a lad aged 17, who had carried loads of bricks on his shoulder up a ladder for three years. He was particularly muscular. This very muscularity becomes a factor in intensifying the deforming effect on the spine, owing to the longitudinal tension set up thereby. Golebiewsky has dealt with the case of the mason's labourer. He shows that the burden-carrying shoulder is the higher, and it is actively raised to resist the load. The dorsal spine becomes convex towards the loaded shoulder. These cases give support to Wolff's views. The same facts have been pointed out in various papers[1] by

[1] Arbuthnot Lane, *Royal Medical and Chirurgical Transactions*, vol. lxvii.; *Pathological Society's Transactions*, 1884-1886; *Clinical Society's Transactions*, 1886; *Guy's Hospital Reports*, 1885-1887.

Arbuthnot Lane. He gives drawings of the spine of a brewer's drayman, who carried casks on his right shoulder and front of the right chest. In this case there was a marked scoliosis with the convexity to the right at the seventh dorsal vertebra. Arbuthnot Lane insists that the deformity arising from the habitual performance of heavy labour is "first the fixation, and then later the exaggeration of what is a normal physiological attitude assumed in this particular form of labour." Elsewhere we have given from Kirmisson an example of such an exaggeration, and it is exactly such cases as this which illustrate the difficulty we meet with in considering the subject. Up to a point, that is, up to "fixation of what is a normal

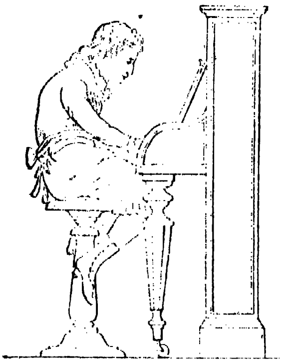

FIG. 338.

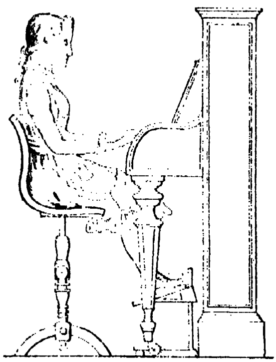

FIG. 339.

Occupation-Scoliosis. Piano-practice in Faulty and Correct Positions.

physiological attitude assumed for this particular form of labour," we may grant that these cases are purely functional; but beyond that, it is clear that lack of resistance comes in, just as much as when the recognised cause is bony softening.

We would particularly direct attention to the occupation of a nursemaid as one predisposing to scoliosis. Schulthess says that joiners, from constantly using the plane, pushing it with the right arm, whilst the left presses it down, frequently develop a right dorsal curve.

The conditions and surroundings of school-life have been most searchingly criticised.

The strain of rapid growth and of puberty, and the fact that a child at school is often subjected to undue fatigue, both physical and mental, result in some loss of resistance of the bony and soft

parts. Fatigue sets in rapidly, and that position, which is most easy, is assumed at first occasionally, and then becomes more or less permanent. This is the beginning of school-scoliosis. Unfortunately, there are other causes incidental to the morbid positions of sitting and standing permitted in schools. We allude to the methods by which writing is taught, which undoubtedly aggravate the mischief already begun. Examples of such vicious attitudes are seen (Figs. 340, 341). In city schools scoliosis is said to be found in 25 to 50 per cent of the children, the large discrepancy being doubtless due to the fact that different observers adopt different standards as normal. In any case, the statement is a sufficiently serious one, and must give rise to grave misgivings.

FIG. 340.—Occupation-Scoliosis. An Effect of a Faulty Position when Writing (Redard).

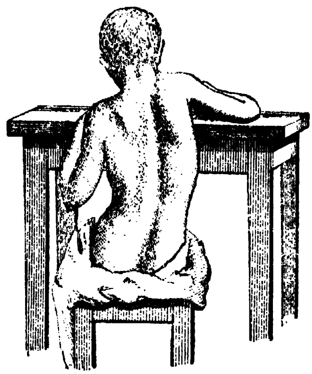

FIG. 341.—Occupation-Scoliosis. Another Effect of Faulty Position in Writing.

In order to save repetition we may briefly enumerate some of the faults prevailing in schools. Want of change of work is one of the most frequent. Difficult and easy subjects should alternate frequently, and be interspersed with opportunities for obtaining fresh air and exercise. Children assume bad attitudes because they are uncomfortable and fatigued, uncomfortable on account of the desks and chairs used, and fatigued by want of proper support and overwork.

School Furniture.—The defects to be avoided in school furniture are—

(*a*) The prolonged stretching of the spinal extensor muscles by continued flexion of the spine.

(*b*) The assumption of distorted and twisted attitudes, which

children with tired muscles readily adopt in order to obtain a change of position.

The following faults are noticeable in chairs and sitting:—The back of the chair is too straight and not sufficiently high. The result is that the back muscles, being unsupported, especially in the lumbar region, readily become tired, and the child leans to one side or the other, the head and shoulders droop, and an habitual stoop is acquired. The height of the seat is too great, and in order to reach the ground the pelvis is twisted, so as to bring one foot down, and the back is still less supported than before. The writing table is too high or too low, and faulty attitudes become the easiest to adopt.

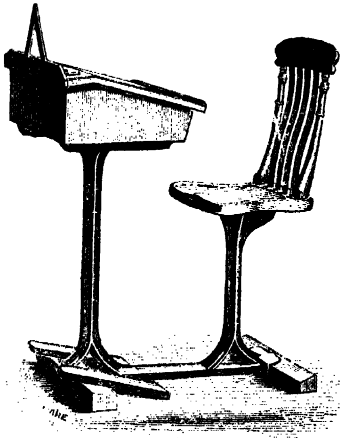

FIG. 342.—School Desk and Chair used in many English Schools.

It must not be forgotten that, in prolonged sitting with the spine unsupported, it is subjected to much greater strain than in

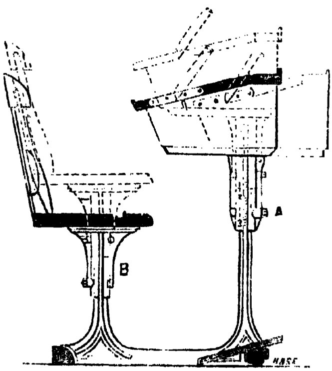

FIG. 343.—Adjustable School Desk and Chair.

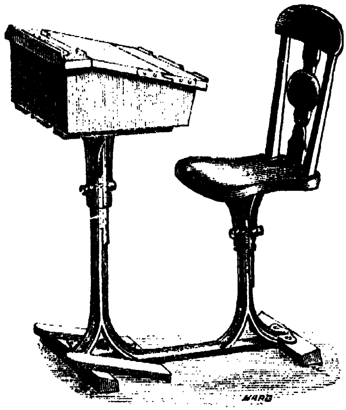

FIG. 344.—The same as in Fig. 343, ready for use.

standing. In standing, the position is never constant. The patient first throws more weight on one limb, then on the other, now sways forward, now backward. The centre of gravity is constantly

changing, even with every inspiration and expiration. The changes call for constantly shifting muscle combinations, so that no one group is pre-eminently strained. In sitting, the pelvis is partially fixed, and a kyphotic attitude is assumed and maintained. Unless the spinal extensors were constantly contracted, the body weight would cause the trunk to topple forwards. It is this unrelieved constant contraction that tires the muscles out.

The disadvantages of the sitting posture may be minimised by appropriate seating arrangements.

Lovett[1] gives an account of the desk[2] devised for the Boston Schoolhouse Commission, which was carefully worked out by Dr. J. G. Cotton in the Scoliosis Clinic of the Children's Hospital. Lovett states that there are now 22,000 such seats in use in the Boston Public Schools. To quote *in extenso*: "The essential theoretical requirements are—

1. The height of the seat from the floor should be such that in sitting the feet rest on the floor.
2. The slope of the seat should be backwards and downwards about three-eighths of an inch; the depth of the seat should be about two-thirds the length of the thighs, the width of the seat should be that of the buttocks. Some concavity of the seat is comfortable, but not essential.
3. The back of the seat should have a slope backward of 1 in 12 from the vertical line. Some seats have two back supports.
4. The height of the desk should be such that the back edge allows the forearm to rest on it naturally with the elbow at the side. The height of this edge from the edge of the seat is known technically as the "difference."
5. The slope of the desk should be from 10° to 15°. The proper distance of the eyes from the desk is from 12 to 14 inches. The width of the desk should be from 22 to 24 inches. The back-rest consists of a curved support of wood $9\frac{3}{4}$ inches wide and 5 inches high, with a concavity of one inch in depth from side to side, and a convexity of one inch in profile, the whole slightly tilted backwards. The maximum convexity lies one-third of the way up, and when properly adjusted comes about opposite or a little above the fourth lumbar vertebra.

[1] R. W. Lovett, *Lateral Curvature of the Spine.*

[2] *Reports of Boston Schoolhouse Commission*, 1903, pp. 4 and 5.

This support is carried on a light casting, running in the groove of a single cast-iron upright attached to the back of the seat. A side screw fixes the height after adjustment.

The height of the desk and the height of the seat are also adjustable. The desk should be at such a distance from the seat as to allow the hand to come down nearly to the edge of the desk without the elbow striking the back-support, namely, at a distance from the seat-back to the edge of the desk equal to the length from the wrist to the elbow (Fig. 345).

This is the best position for writing, but for reading it is rather cramped, and the distance between the desk and chair must be increased a few inches by an adjustable arrangement connecting them."

FIG. 345.—The Boston School Desk and Chair, designed by F. J. Cotton for the Boston Schoolhouse Committee (Lovett). For explanation see text.

In this country satisfactory school desks can be obtained from the North of England School Furnishing Company, Darlington.

Writing Position.—All are agreed that the slanting handwriting should be abandoned, and an upright hand cultivated, the exercise-book being immediately in front of the pupil. The best possible position and light should be arranged.

4. **Static Scoliosis.**—With an oblique pelvis the spine must necessarily be curved in order to compensate for the obliquity. But the curvature is neither so considerable, nor, considering the frequency of inequality of the lower limbs, so often met with as might be anticipated. In this connection the remarks on "Asymmetry," pp. 383-393, should be read.

The curvature is usually convex to the side of the short limb, and equilibrium is maintained by displacement of the pelvis in the opposite direction; but if a compensatory spinal curve arises, the pelvis may remain median. Less frequently the convexity of the curve may be towards the side of the longer limb, and for the explanation the chapter on "Asymmetry" should be consulted.

Inequality of the lower limbs is a very frequent condition. It is probably found as often in children with normal backs, as in scoliotics, but one cannot speak on this matter with certainty, because observers are by no means agreed as to the percentage of scoliotics with unequal limbs. Thus, while Lorenz only found 1 case of shortening in 100 lumbar scolioses, Sklifosowsky in 21 cases of habitual scoliosis found the right leg longer in 17. Steiner, in dealing with Schulthess' material, found the centre of the sacrum failed to correspond with the vertical in 12 of 80 cases of lumbar or lumbo-dorsal scoliosis. The pelvic obliquity has much influence in producing spinal curves, especially in weakly girls, although the subjects show extreme readiness to compensate instinctively for the inequality by a more or less equinus position of the foot on the shorter side, and slight flexion of the knee on the other. In any case pelvic obliquity, unless dependent on unequal development of the pelvic bones themselves, does not come into play in sitting. For these reasons we attach little or no importance to the very slight pelvic obliquity that arises from unilateral flat foot. We do not deny that flat foot is often associated with scoliosis,—although we do not think it is anything like as frequently seen as in 70 per cent (Roth),—but the flat foot is as often double as single, and in any case it cannot be shown to be coincident with any special clinical type. Probably the flat foot and the scoliosis are both expressions of a general skeletal insufficiency.

As to the causes of pelvic obliquity, the expression "inequality in length of the lower limbs" needs both qualifying and extending. Apparent shortening is just as potent a cause of pelvic obliquity as is real; that is, the pelvis may be oblique with the limbs actually equal; again, the limbs may be equal yet the pelvis be oblique, due to deficient development of one innominate bone. It is unnecessary here to run through the very large number of conditions that may give rise to real or apparent shortening of a lower extremity. An interesting point is that the correction of an oblique pelvis, by the cure of such a condition as unilateral congenital dislocation of the hip, may need to be followed by treatment of the spinal curve originally developed as compensatory to the pelvic obliquity.

Static scoliosis is obviously related to the purely functional or occupational form; and we may add that cases of congenital scoliosis, especially when due to variations at the lumbo-sacral junction, are closely related to the static form.

Another point of interest is that pelvic obliquity may exist for years and no scoliosis develop. The pelvic obliquity being cured by treating its cause, the spine may be found to be quite straight. On the other hand, a curvature of a progressive and intractable type may suddenly begin, pointing possibly to some anomaly of nutrition. We refer to much the same sequence of events as happens in "occupation" curves. This we take it demonstrates that "occupation," "static," are terms referring to mere predisposing causes—the real and underlying cause being lack of resistance in the spine. From this point of view the essential scolioses are the "idiopathic" and the "rachitic," and we must not overlook the possibility of a congenital factor in an idiopathic case.

We have said that a short leg and a tilted pelvis are not necessarily followed by scoliosis. The explanation is that the spinal muscles have sufficient tone and equilibrium to maintain the column erect, and the patient has a correctly educated sense of an upright spine. If the muscles become toneless and weak, or if she loses the sense of balance, then scoliosis ensues. Much depends on the condition of the muscles, and, in the author's opinion, on the patient's conception of what is and is not a straight spine. If the patient is not taught, or fails to recognise the correct position of the vertebral column, any slight static change may have a great effect, and curvature quickly follow.

We stated above that exceptionally, when the pelvic obliquity is great, the convexity may be found towards the sound side.[1] The tendency for the summit of a curve in some instances to migrate lower is well known. When the convexity is on the side of the higher hip the curves may be regarded as of that type in which migration of the curve to the lowest possible point has taken place.[2]

In measuring patients for pelvic obliquity, it is always best to do so in the upright position, because other conditions, such as genu valgum or flat foot, may be present which interfere with correct measurement in the recumbent position.

As a ready method the author sits behind the patient, notes or marks the position of the posterior superior spines of the ilia, and then observes what thickness must be placed beneath the shorter leg to bring the pelvis level. If great accuracy is desired, a line

[1] Cf. A. H. Tubby, *Deformities*, 1st edit. p. 152.

[2] Bradford and Lovett (*Orthop. Surg.* p. 336) point out that in severe lumbar cases *secondary* tilting of the pelvis supervenes. These cases must not be mistaken for primary pelvic obliquity.

may be drawn between the two posterior superior spines, and its horizontal position verified by a spirit-level. Actual measurements taken from the anterior superior spines to the internal malleoli with the patient lying down, are often misleading so far as the correction of the inequality and of the spinal deviation is concerned. In practice also, it not infrequently happens that the spinal curve is improved, when the patient is sitting, by placing a block beneath the tuber ischii on that side which is shown to be longer by measurement from the sternal notch to the internal malleolus (cf. pp. 389, 390).

Asymmetry of the pelvis or amesiality (Barwell). Here the pelvis is not oblique, but laterally displaced, so that the mid-sacral line, although vertical, no longer coincides with the mid-line of the whole body. This is a condition of a total curve embracing the whole body from head to foot.

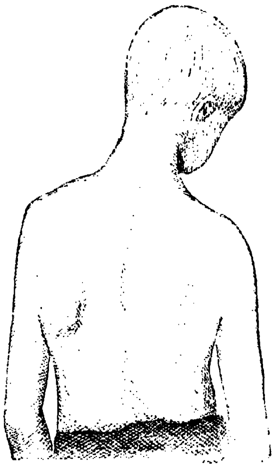

FIG. 346.—Scoliosis associated with Astigmatism (Rédard).

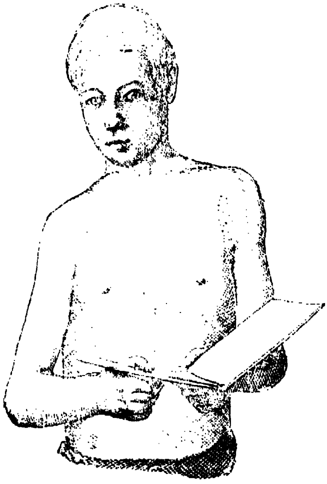

FIG. 347.—Anterior view of case in Fig. 346, showing the position assumed due to Astigmatism (Rédard).

5. **Unequal vision,** especially associated with astigmatism (cf. Figs. 346, 347), is a fruitful cause of bad postures in school, and therefore of scoliosis. Observations carried out at Lausanne show that the greater the proportion of myopia, the greater is the incidence of scoliosis. Gould [1] has claimed that in asymmetrical astigmatism the axis of the dominant eye determines the tilting of the head to

[1] *American Medicine*, May 21, 1901; March 26, 1904; April 8, 1905; *New York Med. Rec.*, April 22, 1895. H. A. Wilson, *New York Med. Jour.*, June 1906.

the right or the left. This, however, does not occur in symmetrical astigmatism.

Unequal hearing often produces a tilting or twisting of the head, resulting in scoliosis.

Torticollis is accompanied, if long continued, by a cervico-dorsal curve, convex on the side opposite the contracted muscle.

Loss of one arm may cause an asymmetrical position resulting in scoliosis.

6. **Scoliosis of Nervous Origin.**[1]—As any cause which leads to unilateral weakness or paralysis, or want of co-ordination of the muscles in maintaining equilibrium, favours scoliosis, we should expect to meet with it in many diseases of the nervous system, and such is the case. Scoliosis is met with in the following conditions:—Infantile paralysis, multiple neuritis, spastic paralysis or Little's disease, sciatica, progressive muscular atrophy, pseudo-hypertrophic paralysis, tabes dorsalis, Friedreich's ataxy, syringomyelia, and tumours of the central nervous system. Lastly, hysterical scoliosis requires consideration.

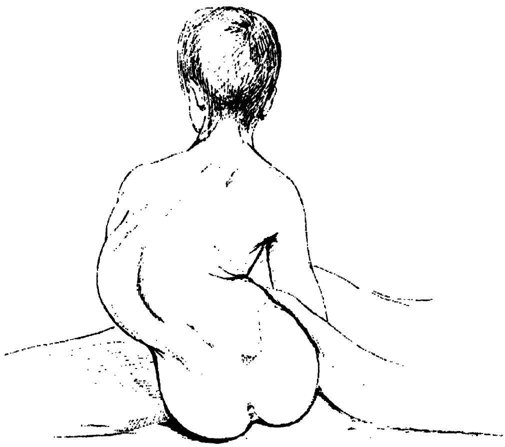

FIG. 348.—Very severe Scoliosis due to Anterior Poliomyelitis—Paralytic Scoliosis (Tubby and Jones).

(*a*) **Infantile paralysis** causes asymmetry. Thus one leg may be short or deformed, or one arm paralysed. Less often the trunk muscles are affected, and when they are, the paralysis may be unilateral, or, at all events, unequal. Apart from this, asymmetrical

[1] Hoffa, "Paralytische Wirbelsäuleverkrümmungen," *Die Orthopädie im Dienste der Nervenheilkunde*, Jena, 1900; Kirmisson, "Des scolioses liées à l'incidence de la paralysie infantile," *Rev. d'orth.*, 1893, p. 284; Sainton, "Sur trois cas de scoliose liée à la paralysie infantile," *Rev. d'orth.*, 1894, p. 293; Messner, "Über Asymmetrie des Thorax und Kontrakturen der Wirbelsäule nach Kinderlähmung," *Centralbl. f. Chir.*, Nov. 5, 1892; Arndt, *Arch. f. Orth.* vol. i. No. 1. Schulthess gives a bibliography of 105 references to neurogenic scoliosis, Joachimstal, *op. cit.* 5. Lief. pp. 1014-1016.

weakness or paresis of the spinal muscles is in itself a sufficient cause of deformity.

No hard and fast rule can be deduced from considerations of the unbalanced action of healthy muscles as to the type of the deformity in infantile paralysis. Thus, it might well be argued that paralysis of the spinal muscles must induce kyphosis, since the powerful abdominal muscles pull the trunk forward. This is seldom the case; see, however, Fig. 348. The patient instinctively throws the trunk backward, and the spine into lordosis, the healthy abdominal muscles acting as a stay in the maintenance of the erect position. When scoliosis is present, a similar mechanism comes into play whether the convexity of the lateral curvature is towards the paralysed side or not. The normal muscles act as a stay in balancing rather than in the direction of unopposed contraction. Actually, the convexity in the spine may be either on the same side or on the opposite side to the paralysed muscles. This is a fact of importance, as Kirmisson points out, in considering the pathogenesis of scoliosis in general, and demonstrates the futility of theories based on supposed unilateral weakness. It also shows how difficult it is to determine which side is more feeble in non-paralytic cases. Hoffa found the convexity on the healthy side in fourteen of seventeen cases, and Royal Whitman agrees with this statement. Messner and Kirmisson found the curvature to be on the paralysed side in the majority of cases, and in all the cases the author has seen the convexity of the chief curve was on the paralysed side, when electrical tests were employed to ascertain the condition of the muscles. The deformity in infantile paralytic cases is much greater than in most other forms of curvature. In some cases there is a great tendency to bony fixation,[1] and compensatory curves are developed.

Multiple neuritis, whether occurring in the adult from the usual causes, or in children from post-diphtheritic paralysis, sometimes leads to results similar to those in infantile paralysis, and the author has seen three marked cases occurring after diphtheria. Infantile or acquired paralysis of the shoulder gives rise to a cervico-dorsal curve, convex on the paralysed side, owing to the patient tilting the thorax so as to rest the affected arm.

(*b*) **Spastic Paralysis.**—Those who see many cases of this

[1] Schulthess illustrates a paralytic case in which the bony changes, rotation and sharp rib-prominences, were extreme. Great deformity may result, and the tendency to fixation is by no means slight.

disease have frequently noticed the association of scoliosis. In many instances a marked kyphosis is present at first, and subsequently scoliosis sets in. The position and direction of the curve depend on the varying degree of the muscular affection on either side.

(*c*) **Ischias Scoliotica.**[1]—Since Gussenbauer, in 1878, called attention to the association of scoliosis with sciatica, a large amount of attention, perhaps more than is warranted, has been given to the subject. The term "ischias scoliotica" should be reserved for cases of scoliosis due to an anomaly of posture consequent on an idiopathic neuralgia affecting the lumbar or sacral plexus. The duration of the nerve affection is rarely sufficient to cause structural changes of the spine, and if true scoliosis appears it is usually slight. The curve is generally convex towards the affected side. It has been thought that the condition might be paralytic, but no paralysis or paresis of the muscles of either side has been demonstrated. On the other hand, curvature of the spine towards the affected side, with flexion of the knee and hip, and consequent tilting of the pelvis, is the position of relaxation of the lumbo-sacral nerves; so that on a purely mechanical theory the condition may be regarded as that position, instinctively assumed and maintained by muscular spasm, in which the patient finds most relief. Probably in treatment we should follow up this hint, and fix the patient in this deformed position temporarily, and subsequently straighten by suspension when the painful condition has passed off.

A very similar clinical picture is presented by other painful conditions, such as psoas abscess, lumbago, and rheumatic myositis. In sciatica, whilst in the majority of cases the lumbar spine is convex towards the affected side, in occasional cases it is convex to the opposite one, as in ordinary static scoliosis.

Distortion similar to that of infantile paralysis may follow *hemiplegia, progressive muscular atrophy, and pseudo-hypertrophic paralysis*, the chief factor at work being unbalanced muscular action. In *locomotor ataxy* spinal curvature is rare. Mr. J. H. Targett[2] collected six cases. The prevailing type of curvature appears to be a kypho-scoliosis, the scoliotic curve being usually convex to the left.[3]

[1] Langenbeck's *Archives*, 1889, "Ischias scoliotica"; Bender, "Wanderniere und Skoliose," *Centralbl. f. Chir.*, 1903, p. 52; Lorenz, "Über ischiadische Skoliose in Theorie und Praxis," *Deutsch. med. Wochenschr.*, 1905, No. 39; Bahr, *Centralbl. f. Chir.*, 1896, xiv.; Ehret, *Mitt. aus den Grenzgeb. d. Med. u. Chir.* iv. 5.

[2] *Guy's Hospital Gazette*, August 6, 1905, pp. 133 to 135.

[3] Abadie distinguishes three phases in the tabetic spine: a period of simple

(*d*) **Syringomyelia.**[1]—Cases of syringomyelia frequently show curvature of the spine. Observers vary in their statements as to its incidence. The divergence is from 25 per cent to 80 per cent. Bruhl found scoliosis present seven times in 8 cases. He regards the condition as trophic (New Sydenham Society, vol. clxi. pp. 38-40). Mr. Targett[2] states that it is present in about 50 per cent, and in the article referred to gives notes of three cases. The curvature is generally lateral, with a small amount of kyphosis. Pure kyphosis, however, and lordosis are rare. The curvature usually begins in the dorsal region, and is associated with very little discomfort. It may go on to such severe distortion that the spine assumes the appearances seen in advanced conditions of osteomalacia.

(*e*) **Friedreich's Disease.** — In Friedreich's disease scoliosis develops late, and is generally to the right in the dorsal region, with some lordosis of the lumbar spines.

Hysterical Scoliosis[3]

Curvature of the spine arising directly from hysteria is sometimes met with. It usually occurs in females, and during adolescence. It has, however, been seen in a woman, aged 35, by Hoffa, and by Miraillié in one, aged 45 years. Men are not exempt, and it is the middle-aged who are affected.

The onset is sudden, and is generally preceded by slight traumatism. The type of curve seen is the "total" one, convex to the left; it disappears under an anæsthetic, and is amenable to hypnotic suggestion. It can generally be straightened by suspension.

deviation, followed by an acute phase, usually preceded by slight injury, which passes into the kypho-scoliotic stage already mentioned. The acute phase is essentially a more or less complete fracture of a vertebral column weakened by trophic changes, and in addition to the deformity, signs of medullary compression may occur, as in cases described by Krönig, Benedickt, Stein, and Graetzer.

References to the influence of nerve conditions in the production of scoliosis will be found as follows: — Joachimstal's *Handbuch*, *op. cit.* 1. Lieferung, p. 87; Frank, "Über tabetische Osteoarthropathie der Wirbelsäule," *Centralbl. f. die Grenzgeb. d. Med. u. Chir.* Bd. vii. 1904, Nos. 15, 16, and 17; also Kroenig, *Zeitschr. f. klin. Med.* i. 14, 1888.

[1] Putti, "La deformità nella siringomielia e nella tabe," *Archivio di ortopedia*, fasc. ii. 1904, fasc. v. p. 431, 1905.

[2] *Loc. sup. cit.*

[3] Oskar von Hovorka, *Zeitschr. f. orth. Chir.* Bd. xiv. Hefte 3 and 4; E. Scheu, *ibid.* Bd. xiv. Heft 2; Denis G. Zesas, *Arch. inter. de chir.* vol. ii. fasciculus i.

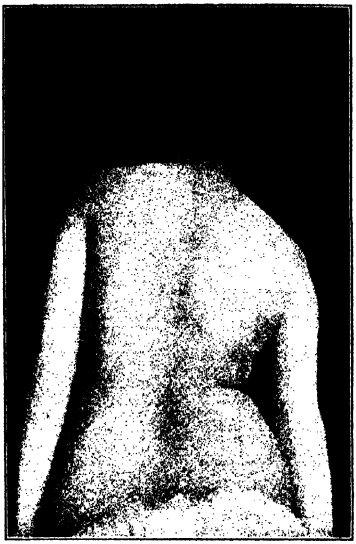

FIG. 349.—Hysterical Scoliosis.

FIG. 350.—Full-length posterior view of a young woman with Hysterical Scoliosis. Note the elevation of the right side of the pelvis, and of the right heel.

FIG. 351.—The same patient as in Fig. 350. This photograph was taken a few minutes after that seen in Fig. 350, and shows that the patient possessed the power of complete voluntary redressment under persuasion.

When the patient flexes the spine the curve is straightened out. Illustrations from a case of the author's are given (Figs. 349, 350, 351).

If the case is not treated, its duration is uncertain. The curve, however, may spontaneously disappear, and that very suddenly, or it may run on to a true scoliosis.

The differential diagnosis, when anæsthesia is not employed, depends upon the history, the presence of the usual stigmata,

FIG. 352.—Total or C-Curve Scoliosis associated with right-sided Empyema (Evelina Hospital for Children).

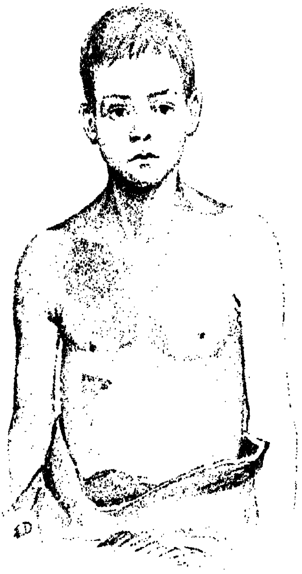

FIG. 353.—Front view of same case as in Fig. 352. The Scar due to the Empyema is seen below the right nipple (Evelina Hospital for Children).

anæsthetic and hyperæsthetic patches, whilst the family history is often of importance. The presence of a severe lateral curve, without any characteristics of structural change, is typical of hysterics. Sometimes severe muscular spasm is seen.

Two forms of hysterical scoliosis exist. In one, the more frequent, the spine is curved, but the distortion is limited to the trunk. In the other the spinal curvature is associated with hysterical contraction of the hip and an oblique pelvis, and is perhaps secondary to these conditions.

Scoliosis arising from Diseases of the Chest

Of these the most frequent are repeated attacks of *pleurisy and empyema.* The following are the notes of a case:—

CASE 9.—*Scoliosis secondary to Empyema.*—Henry B., aged 9 years, came to us at the Evelina Hospital in November 1893. Eighteen months previously he had been an in-patient on account of pleuritic effusion followed by empyema on the right side. The pus was evacuated at the sixth right space, and there was still a sinus left. The right side of the chest was flattened, and there was a well-marked spinal curvature in the dorsal region, with its convexity to the left (see Figs. 352, 353).

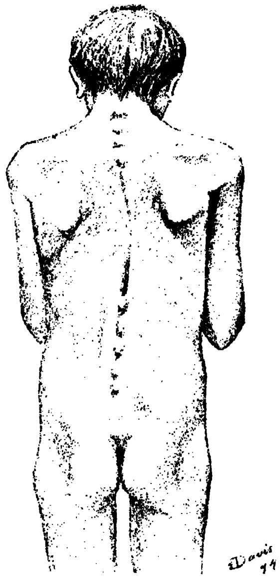

FIG. 354.—Right Dorsal Scoliosis following Left Pleuritic Effusion in a boy, aged 13 years.

This case illustrates the course of events, the convexity of the spine being always to the sound side. Estländer's operation increases the scoliosis very markedly. A similar condition may be seen after repeated attacks of pleurisy. It undoubtedly arises from cicatricial contraction and collapse of the thoracic contents on the affected side (Fig. 354). As far as the scoliosis is concerned, it is characterised by the almost complete absence of signs of rotation, and by the fact that the chest is larger on the convex side of the curve than on the concave, which is the reverse of ordinary scoliosis. *Cardiac disease* in children, especially of the congenital type, is an occasional cause of lateral curvature; and in adults *prolonged phthisis*, in which the tendency to fibrosis and cicatricial contraction of the lung is marked, is also associated with this deformity. Further, both phthisis and emphysema cause kyphosis, and thus favour scoliosis.

Scoliosis in Association with Nasal Obstruction

DEFLECTED SEPTUM NASI AND ADENOIDS OF THE NASO-PHARYNX

The order of events is first nasal or naso-pharyngeal obstruction, then contracted chest, kyphosis, and scoliosis. Persistent flexion of

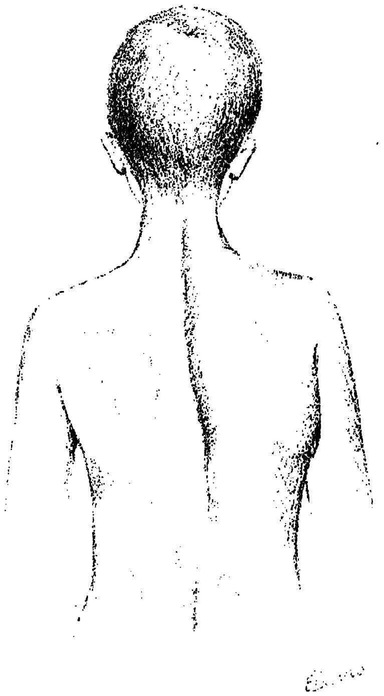

FIG. 355.—Dorso-Lumbar Scoliosis, associated with Adenoids, and relieved after their removal.

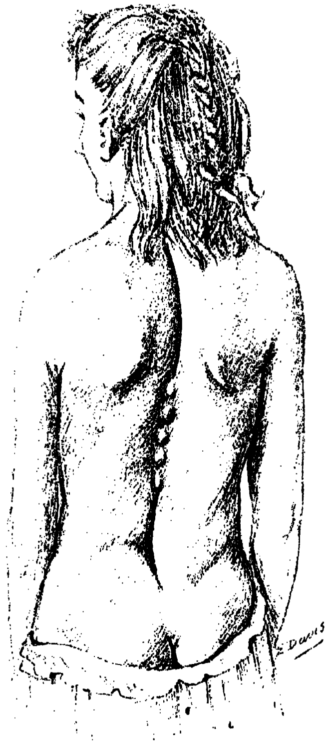

FIG. 356.—Dorso-Lumbar Scoliosis with Projection of Dorso-Lumbar Vertebræ, associated with Adenoids, in a girl, aged 9 years, seen at the Evelina Hospital for Children.

the kyphotic spine leads to weakness of the muscles, and scoliosis results. The proof that the deviation of the spine is dependent upon the obstruction, and that it is not a mere coincidence, is furnished by the results of treatment. The cure of the thoracic

deformity and kyphosis follows rapidly on the removal of the obstruction in the nasal fossæ and post-nasal space. The author has had several cases at the Evelina Hospital for Sick Children which verify this statement.

Scars about the upper arm and thoracic wall, especially from extensive burns, may result in scoliosis, the concavity being on the affected side.

Diagnosis of Scoliosis

Scoliosis should be distinguished from lateral deviation in Pott's disease, and the distinctions have been fully given on page 408. The presence of scoliosis does not necessarily exclude caries, which may develop in a scoliotic. In some instances of scoliosis, at the intersection of two curves, there is a posterior projection of the spine, but this must not be mistaken for caries. Some cases of extreme kypho-scoliosis do very much resemble Pott's disease. The absence of pain or rigidity, and the characteristic alterations in the outline of the body, are valuable points of distinction. As to the diagnosis of the form of curve, its causation, the stage at which it is seen, the condition of the spine as to flexibility or otherwise—these points have all been dealt with under their appropriate headings, therefore repetition is needless.

Prognosis of Scoliosis

The question most frequently put to the surgeon when he sees cases of scoliosis is, "Will he or she grow out of it?" To this the reply is, that spontaneous cure is to be neither expected nor relied upon. If curvature exist, the proper answer is that with due care and attention to treatment great improvement may be effected, and in some cases the deformity will disappear. Bradford and Lovett [1] remark that two errors in prognosis are common: "First, that the deformity is of the most serious nature; second, that it is a trivial affection, and will be readily outgrown by the patient." Both statements contain just such a partial measure of truth as to render them misleading, and they arise from a want of careful appreciation of the factors at work in individual cases.

In the succeeding remarks it will be our endeavour to reiterate such points as may be useful in forming an approximately correct opinion. We say approximately, as two kinds of cases defy

[1] *Orth. Surgery*, 3rd edition, p. 348.

calculation:—The one which, in spite of careful treatment, is perverse from the first, stubbornly refuses to yield, and pursues a steadily downhill course. Fortunately this kind is exceptional. The other class of case is that in which the deformity having arrived at a certain stage becomes arrested spontaneously.

The elements of prognosis may be discussed conveniently under several headings:—

The Cause.—Rachitic deformities present many difficulties in treatment. As the child grows, the effect of the increase in weight on the distorted part is aggravated. The tender age and small frame of the patient limit therapeutic methods. Scoliosis in girls, coming on about puberty, requires much caution in the expression of opinion. Cases in which the influence of heredity is observed are less favourable than others. If the condition is connected with a cause which can be counteracted or removed, for example, myopia, occupation-curves in young people, or asymmetry of the limbs, the outlook is better than when the cause is intractable, such as unilateral spinal paralysis and cicatricial contractions following pleurisy and empyema. The chief elements in prognosis are the relative hardness of the bones and the tension of the muscles and ligaments.

The Age of Onset.—Scoliosis must be regarded as a chronic condition, often steadily progressive until the period of growth is attained, and then becoming arrested in most cases. The earlier the onset, the greater the risk of severe deformity. Structural curves, whether simple or compound, in young children should be regarded as serious, and are almost certain to become worse. They are likely in later life to affect the general health, and many patients succumb to phthisis and circulatory trouble. In older children and adolescents organic curves, which have been slow in developing through childhood, are likely after puberty to increase until middle life, and as age advances all structural changes become intensified. The effects of severe structural scoliosis at any period of life are generally such as to induce ill-health and to threaten the patient's life, and the worst types of deformity in middle life are those which originate in rickets and infantile paralysis in childhood.

Sex.—Generally the deformity assumes in girls a more severely progressive form than in boys, owing to their want of muscular development and the feeble health often entailed by menstrual disorders. And some of the severest cases seen by the writer

have been present in boys, probably due to unsuitable occupations in rickety subjects (Figs. 357, 358).

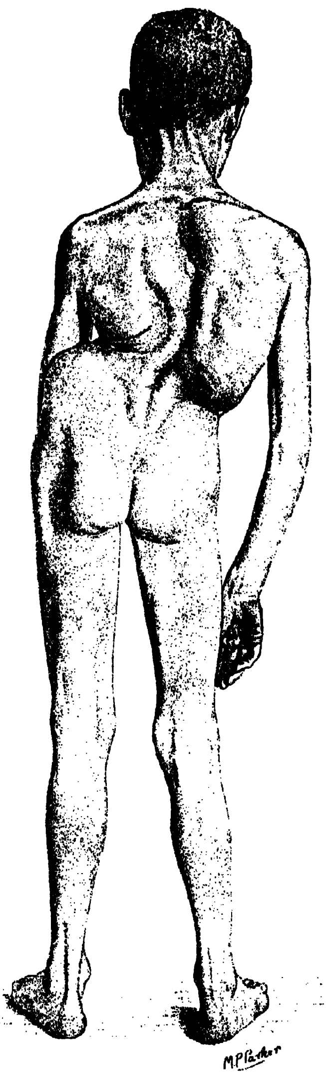

Fig. 357.—Very Severe Dorso Lumbar Scoliosis of the Overhanging Type in a School-boy, aged 14 years.

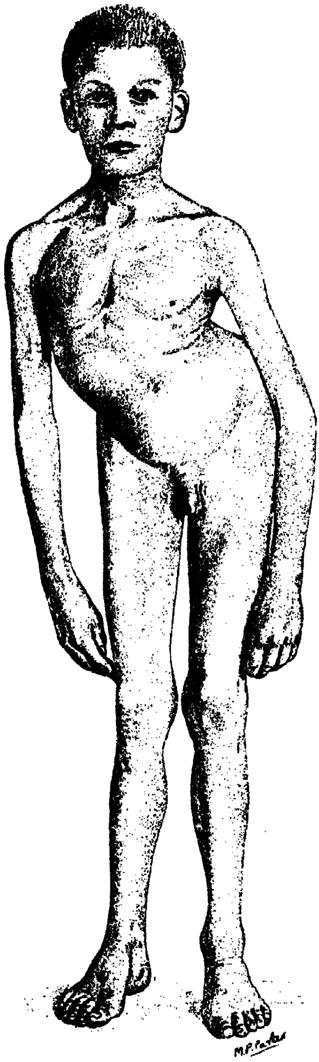

Fig. 358.—Front view of the case in Fig. 357. The Apex beat of the Heart was $2\frac{1}{2}$ inches below the nipple and displaced slightly outward.

Mental Factors.—Frequent allusion has already been made to the effect of the patient's habit of mind upon the progress of scoliosis. In those where mental occupation rapidly induces fatigue, positions of rest are readily assumed which are directly conducive to the development of deformity. In girls with shy and retiring dispositions the bodily attitude reflects the state of the mind. They seem to be unwilling to stand squarely or to face other people, and when they sit they sink sideways as it were into the chair, frequently with one shoulder forwards, with the axis of the shoulder girdle placed obliquely to that of the pelvis, with the legs drawn to one side, and one curled round the other. In such cases the writer has always found the treatment difficult and the prognosis most unsatisfactory. Again, in girls who take no pride in their appearance, who are mentally indolent, and are averse to receiving any hints or instruction designed for their improvement, the outlook is bad.

Loss of Sense of Equilibrium.—In many cases the sense of balance is either perverted or lost, and until the patient's faculties have been re-educated in this direction all efforts at treatment are fruitless. The mode of dealing with this aspect of the question will be alluded to under "Treatment."

The Physical Condition.—Persistent anæmia and chlorosis often neutralise any efforts toward successful treatment. Dysmenorrhœa and menorrhagia, by their exhausting effects, prevent that steady attention to the improvement of muscular action and perfect maintenance of equilibrium so essential to effecting improvement. Girls in whom ill-health has become tinged with hysteria are the worst subjects of all. Curvature frequently becomes more marked during pregnancy.

Many curvatures in town-bred people improve when the patient is sent into the country, and the appetite and general tone thereby bettered. If the health remains good all through, there is considerable hope of dealing successfully with a curvature of moderate severity.

The Probable Rate of Growth of the Patient.—Patients with long, narrow, yielding backs, which may be moulded into almost any shape, are bad subjects when scoliosis sets in. The probable rate of growth may be estimated by noting the patient's height, and comparing it with the average at that age. The height of the parents should also be observed, and Galton's conclusions remembered. These may be summed up thus: The

deviation in height of the child from the average will probably be two-thirds of the total deviation of the parents from the normal. This must hold good, otherwise the race would become giants and dwarfs.

Occupation.—The effect of occupation has already been considered. The later in life the occupation involving faulty position is adopted, the less potent is its influence.

The Nature of the Curve.—Total or functional curves may not develop into organic, even if they increase. Generally they change to structural curves. Total curves may, however, be cured by appropriate treatment, but they are not likely to disappear spontaneously. Structural curves usually increase, and often rapidly. The long C-curve of functional total scoliosis sometimes undergoes transition very rapidly, and the writer has seen a C-curve change into a double S-curve in less than ten weeks.

Whilst large single functional curves are more easily straightened under favourable treatment, multiple curves of equal length are likely to be spontaneously arrested if growth is nearly completed.

The Site of Curvature.—Lumbar curves are less favourable for treatment than are dorso-lumbar or dorsal. Curvatures high up, cervical and cervico-dorsal, are particularly troublesome owing to the difficulty of making effective pressure upon the vertebræ, and the natural kyphosis in the dorsal region facilitates increase of the scoliosis.

The Amount of Existing Curvature.—Attention should be paid, not so much to the degree of displacement of the vertebral spines as to rotation. Cases of scoliosis in which the normal antero-posterior curves are reversed are very grave.

The State of the Curvature.—Rigidity and fixation of the spine when seen in adults are adverse elements, and the most that can be promised is that treatment will prevent the condition from becoming worse.

The Influence of Treatment.—In all cases measures should be taken early. Total scoliosis, in which structural change is slight, is quite curable by appropriate methods. Scoliosis, if of moderate degree and occurring in young children, can be much ameliorated by adequate treatment of long duration; and even if severe, much improvement should be effected by reason of the plasticity of the parts. Structural curvatures in older children and young adults can undoubtedly be improved, although not wholly cured, by persistence and perseverance. In severe adult cases, even if no

improvement can be promised, the deformity should certainly be prevented from becoming worse.

When the deformity is traceable to congenital anomalies of the vertebræ, scapulæ, thorax, or pelvis, to infantile paralysis, or to empyema, cure is not to be expected, but improvement is to be assiduously sought. Rickety cases are always troublesome, and do not as a rule yield a perfect result.

CHAPTER V

SCOLIOSIS OR LATERAL CURVATURE OF THE SPINE—*Contd.*

Treatment Preventive, General, and Local, by Recumbency, Postural Methods, Massage, Exercises Passive and Active—Supports—Rapid Correction by Lovett's Method and by the Author's Method—Operative Interference.

Treatment of Scoliosis

Preventive.—The preventive treatment of scoliosis consists of avoiding or neutralising any predisposing cause. This is not always easy or possible, but even if an obstinate condition, such as infantile paralysis, is present the effect may be modified by early treatment.

Rickets should be promptly treated, and while the bones are soft, faulty positions carefully avoided. One of the most common is the way in which the child is carried by the nurse. Her forearm is bent at an angle, and the child's pelvis is therefore tilted laterally, and the spine deviated (Fig. 334, p. 466).

When the spine is very flexible, the deforming tendency of the body-weight may be counteracted by placing the infant in the horizontal position, and carrying it on a wicker tray lined with a thin, firm mattress (Fig. 398, p. 532).

In the bulk of cases the onset is insidious, and the failure to recognise it is doubtless due to the fact that it is not customary to strip and examine children periodically whilst growing. This being so, attention is only called to the child when the deformity is already more or less advanced. Children should be drilled, their muscular system carefully developed, and vicious attitudes, or rather the constant repetition of a given attitude—since the vice lies in the repetition—corrected. For instance, the habit of standing at ease with the pelvis tilted, a common position adopted by children and young girls, should be discouraged, or if permitted frequently reversed. Exercises involving the use of one arm mainly are to

be discouraged, but dumb-bells and double sculling, which favour symmetrical development, are to be recommended. Among the most harmful positions is that involved in violin-playing; and the writer has seen numerous intractable cases following practice of this instrument. Excessive riding on the near side is in girls often responsible for the early development of a pronounced lumbar scoliosis, and bicycling, owing to the fatigue and bent spine, is sometimes an important factor in the production of the deformity. But if children sit perfectly square and upright on the bicycle, and do not overtax their strength, no great harm is likely to result.

School Life.—Many believe that the words education and school are synonymous. It therefore follows that the child's life is made subservient to so-called progress at school; and in these days of keen competition everything seems to be sacrificed to scholastic rules.

At school, opportunities should be given of frequently changing the character and type of the work, and mental occupation should alternate with physical exercise in the open air. The child should neither sit nor stand too long. What is too long in an individual case can be quickly estimated by an intelligent teacher, who will note the look of weariness on a child's face.

We have already spoken of faulty positions at school in writing, and reading, and piano-playing; and we have alluded to the harmful effects of prolonged sitting. But, as school-life appears inevitable, the evils incidental to it must be diminished by providing suitable sitting accommodation (see pp. 470-477).

Lorenz describes scoliosis as a school deformity, and Schulthess, after analysing the question, sums it up as follows: (1) We may be certain that writing and school occupations are not the only causes of left total scoliosis; (2) The truth is to be sought in the fact that the vertebral column of the child has a tendency to bend to the left, and the position assumed in writing favours this; (3) Total lumbar scoliosis in girls is especially favoured by school occupations; (4) School life makes any curvature, already present, worse; (5) In school the most important factors are prolonged sitting, fatigue, and the assumption of pathological attitudes to afford ease.[1]

Presence of other Deformities.—Not only should all the

[1] See also an excellent article and criticism of views—"Schule und Skoliosis," by A. Schanz, *Zeitschr. f. orth. Chir.*, vol. xvii. pp. 171 to 200. There is no doubt, however, that the view that scoliosis is a Schulkrankheit needs a large amount of qualifying.

precautions above mentioned be taken in the case of the normal child, but we must recognise and treat any conditions such as short leg, flat foot, genu valgum, coxa vara, and the deformities arising from disease of the bones and joints of the lower extremities. The position during sleep is important. For children the supine position is undoubtedly the best, but the majority prefer either the right or left lateral. Soft beds and many pillows are harmful. The head should be low, the mattress firm and resistant, and feather pillows avoided.

Corsets.—As to corsets, young people do not need them, and a waist belt and braces for carrying the clothes are often better than shoulder-straps.

General Measures.—All causes of impaired tone, such as late hours, are to be avoided. General limpness and weakness of the muscles call for a tepid bath in the morning, with vigorous rubbing till the skin glows, moderate walking exercise, simple and sufficient diet; and girls, especially those town-bred, should be sent away to the country. The onset of puberty in both sexes, and especially in females, is accompanied by considerable strain on the physical powers, and careful watching at this period is necessary.

In growing lads, those occupations should be avoided which cause over-fatigue; and in most scoliotic cases one to two hours' rest daily in the supine position is advisable.

The diet should be plain, wholesome, and plentiful, and constipation avoided or treated.

Local Treatment of Scoliosis

The factors in the production of the deformity are: (1) The assumption of abnormal positions of the spinal column from various causes; (2) The fixation of vicious positions from the constant influence of such causes; (3) The perpetuation and increase of malpositions by the weight of the upper part of the trunk, the shoulders, the head, and neck; (4) The loss of tension of the long spinal muscles.

The four factors act synchronously, and the means of treatment at our disposal must therefore be employed so as to render them, if possible, simultaneously inoperative. Many forms and so-called systems of treatment have been advocated, and too often without discrimination. Scoliosis is a deformity of complex origin and far-reaching results. No one line of treatment therefore is applicable to all varieties. Each case must be judged on its merits,

and the causative factors recognised before attempts at alleviation or cure are made. Even then our difficulties are by no means over. Royal Whitman says: "It is not the difficulty of formulating principles, but of applying them, that makes the therapeutics of rotatory lateral curvature of the spine perplexing."

What is required in treating scoliosis is an intelligent use of the means at our disposal. In effect, the subject is to be approached with an open mind, and without any bias in favour of one form of treatment.

The means at our disposal for the correction of the deformity and the maintenance of that correction are as follows:—

(1) Treatment directed to the restoration or improvement of the general health.

(2) Daily rest, sufficient to remove the weight of the head and neck from the distorted spine, and relieve the tired muscles.

(3) Postural methods, which teach the patient how to assume correct attitudes and acquire an upright carriage, *i.e.* the muscular sense must be educated.

(4) Exercises planned so as to increase the strength of the weaker muscles, and at the same time bring into action to a less degree the normal ones. The exercises are of two forms, active and passive, and in many cases massage is valuable.

(5) Correction of the curves, either by passive manipulation, or by the combined efforts of patient and surgeon.

(6) A discriminating use of supports in those cases where (*a*) no improvement can be expected, but the best that can be hoped for is the prevention of worse deformity; (*b*) as a temporary measure in those weak-back cases, where any improvement effected by exercises is immediately lost, and the patient relapses into a vicious position; (*c*) in those cases where the patient's occupation is such as to cause much fatigue.

(7) Rapid correction, with fixation in the corrected position in a plaster of Paris corset.[1]

We repeat that those cases are in a minority where one of the above means of treatment is applicable to the exclusion of the rest. In the majority it is only by a judicious use of several that a satisfactory result can be effected.

We have already spoken of—1. *General Treatment*, and we may now pass on to—

[1] Operative treatment, implying tenotomy, excision of prominent ribs, has been tried and failed, as one would expect. It has justly been condemned.

2. **Recumbency.**—Of all measures this is the one most calculated to neutralise the effect of superincumbent weight, and is useful in the following directions: (1) To prevent over-fatigue; (2) In feebly developed people a period of recumbency from one to two hours after massage and exercises is called for; (3) When the spine has become distorted from static causes, deformity can often be temporarily reduced in the recumbent position, by placing the limbs so that the transverse diameter of the pelvis is at right angles to the median line of the body; (4) Periods of recumbency in a corrected or over-corrected position in a suitably constructed plaster of Paris or other form of bed: this method of treatment varies from marked over-correction during a half to one hour to much more gentle correction, under the conditions requisite for repose during a whole night.

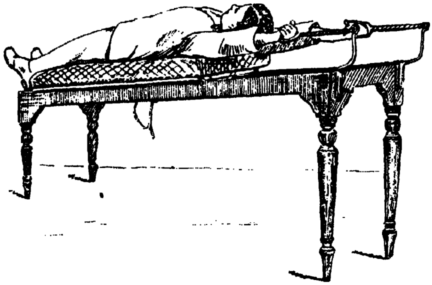

FIG. 359.

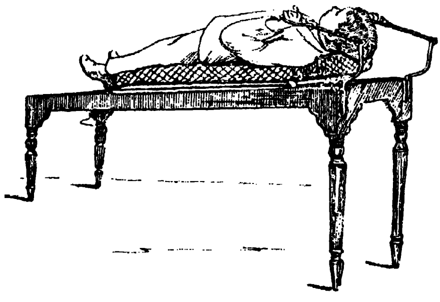

FIG. 360.

FIGS. 359, 360.—Adams' Couch and Exercising Apparatus for Scoliosis.

Recumbency, as an exclusive method of treatment, has long been given up. It is *the* way to bring about the very "skeletal insufficiency" we are trying to cure. The "orthopædic bed" treatment of the earlier part of the last century has been exhaustively tried and found wanting. Again and again deformity has been seen to increase under treatment by recumbency even when combined with extension. Still we cannot affirm that the deterioration might not have been much more severe in the absence of recumbency. And undoubtedly in certain rapidly "collapsing" cases, recumbency as a relief to the body-weight is a judicious method of treatment, whilst energetic massage and general nutritional measures are being carried out.

We may sum up by saying that—

(*a*) Intermittent recumbency is indispensable.

(*b*) It may be advantageously combined with passive correction.

(*c*) In certain cases temporary continuous recumbency is indicated.

(*d*) The number of such cases is less numerous now than formerly, because many of the indications met by recumbency are now better dealt with by the use of supports. The adoption of either the prone or supine position depends upon the type of scoliosis.

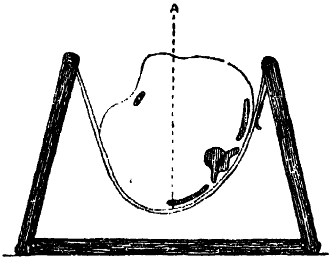

FIG. 361.

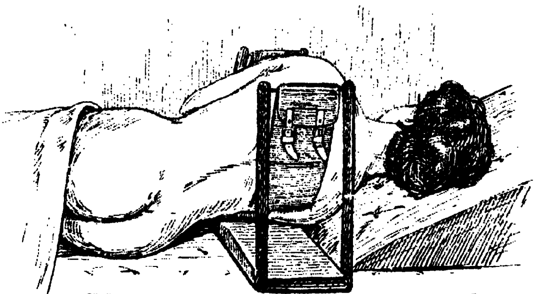

FIG. 362.

FIG. 361.—Wolff's Cradle or Glisson's Sling. FIG. 362 delineates the method in which it is used at night.

The late William Adams designed a useful combination of couch and exercising apparatus[1] (Figs. 359, 360). In lateral decubitus Wolff's suspensory cradle, or Glisson's sling (see Figs. 361, 362), is useful. In slight cases of scoliosis partial recumbency in a Ward's reclining chair (Fig. 363) is of value.

During sleep the head must be kept low, and a firm pillow placed beneath the ribs on the convex side. It should, however, be remembered, as shown by Schulthess, that lateral pressure

[1] *Proceedings of Med. Soc. of London*, vol. I.

applied at the mid-point between the sternal and spinal attach-

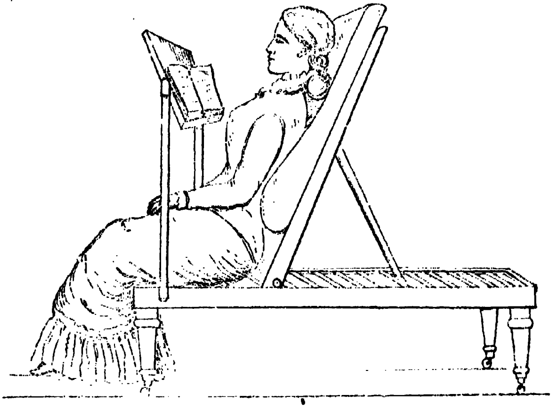

FIG. 363.—Ward's Reclining Chair.

ments of the ribs, increases the rotation of the vertebræ. To be effective it should be applied at a point just outside the angles of the ribs. Infants with scoliosis are best carried about on a wicker tray (Fig. 398).

3. **Postural Methods.**—The patient is taught to walk, stand, and sit properly. The use of both arms equally should be enjoined, and regular drilling for a quarter to half an hour daily is useful. Patients who habitually stand at ease should be corrected, and if there is shortening of one leg it is to be remedied by a cork sole. In cases of primary lumbar curvature Volkmann's oblique seat (Fig. 364) is useful, although Schulthess decries its employment.

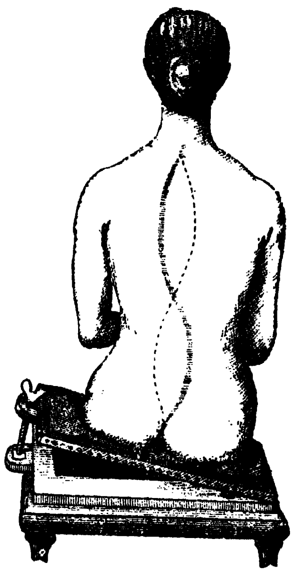

FIG. 364.—Volkmann's Oblique Seat as used in the treatment of some forms of Scoliosis.

In scoliosis one of the most important questions is the acquisition of a proper sense of balance and a true appreciation of what is the upright position. In many cases it is useless either to tell the patients what to do to attain these objects, or even passively to

place them in position. For, immediately the authority of the surgeon is withdrawn they relapse at once into faulty positions. The only thing to do is to convince them by ocular demonstration of their faults, and enlist their co-operation in overcoming them. For this purpose the author has found the following plan very useful:—

To drill the patient back to the upright position, her body should be bared to the top of the gluteal cleft. For the instructor's guidance the position of the tips of the spinous processes is indicated by marks on the skin, and for the patient's guidance a thick line is traced down the sternal notch to the symphysis pubis. The patient is placed opposite a perfectly vertical mirror, and told to stand up straight. Her attitude is then corrected by comparison with a plumb-line adjusted to the gluteal cleft. She is then told to walk up and down the room, come back into position, and again assume the erect posture. The instructor once more makes the needful correction. This is repeated again and again as a regular daily exercise, until the patient learns and knows absolutely what the upright position is. It is evident that whole-hearted co-operation on her part is essential, and if this be secured half the difficulties are over. But a flabby, indolent, or careless girl, who takes no trouble, is often hopeless from the first, and may be later the victim of corset-makers.

Massage.—Massage is of much importance in the treatment of spinal curves. It is no new thing, and latterly its systematic carrying-out has become an integral part of treatment. Its aims are a general strengthening and development of the muscles, and a stimulation of nutrition by interchange of metabolic products. It therefore aids materially in the diminution of the deformity.

Swedish or **muscle massage** was especially taken up by Landerer in 1887 for scoliosis, and has since attained an extraordinarily widespread use. In many modern Orthopædic Institutes all scoliotics are regularly massaged, although it is doubtful if the Swedish plan of paying more attention to the supposedly weaker side is theoretically sound.

There is nothing special or peculiar to Swedish massage save that in Sweden a combination of massage with active and passive gymnastic movements has been elevated into a sort of "cure all" cult. Rubbing and exercises are as old as the hills, and the Swedish advocates have been rather more systematic, and that is all. A great deal of charlatanism has masqueraded under the name of Swedish massage, chiefly due to the fact that legitimate practitioners of the healing art have not sufficiently impressed on the public the value of

muscular development. Because the value seemed so obvious to the surgeon it does not follow that it was equally appreciated by the public.

Massage.—The manipulations of massage consist of :—

1. *Effleurage.*—Slow, superficial rubbing with the palms from periphery to centre, the skin having been greased.

2. *Massage à friction.*—A deeper and more forcible variety of above.

3. *Pétrissage.*—As far as possible an individual muscle is picked up and kneaded.

4. *Tapotage.*—Beating, with either the closed fist, flat hand, or cupped hand (as in clapping).

In the Swedish system, shampooing is combined with passive movements, and to a less extent with active movements. It would be out of place here to go into detail. For example, under the Swedish system the tapotage above mentioned becomes elaborated into :—

Tapotage = Muscle tapping :—

(*a*) Hacking.—1. With finger tips.
2. With ulnar surface of little finger.
3. With ulnar border of whole hand.
4. With dorsal surface of three inner fingers.

(*b*) Clapping.—1. Quick and superficial.
2. Slower and deeper.

(*c*) Beating.— Fist half-closed.

We have all been practising Swedish gymnastics from our birth onwards, only, luckily, until we meet a professor of the "system" we are unaware of the fact.

4. **Exercises or Gymnastics, Passive and Active.**—Their objects are to improve the flexibility of the spine, and to strengthen certain groups of muscles so as to maintain the improvement. It is found in practice that most forms of exercises accomplish these results simultaneously.

In early and slight scoliosis, gymnastics, whether passive or active, or both, are very useful, and in more advanced and severe scoliosis their therapeutic value is greater still, for the muscles have to be developed sufficiently to neutralise the handicap of a deformed spine—a severer task than the mere balancing of a normal one. Muscular inefficiency is the condition to be dreaded and guarded against. It is a matter of common experience how scoliosis which has been stationary for years takes a rapid turn for the worse, if for any reason the muscular energy becomes impaired; for example, after some intercurrent illness such as typhoid fever or the weariness incidental to pregnancy.

In slight scoliosis, exercises may be depended upon as the sole method of treatment, provided that a steady improvement is seen.

If such improvement is not maintained after a fair trial, it must be assumed, as Lovett points out: (*a*) That the exercises are not good ones; (*b*) That they are not properly carried out; (*c*) That the amount of treatment is insufficient; (*d*) That the case is too severe for purely gymnastic treatment.

Exercises or gymnastics may be carried out either with or without the use of apparatus; and when without apparatus they may be either passive, where restitution is made by pressure with the surgeon's hand; or active, where the patient either resists force applied by the surgeon's hand, or actively places himself in such positions as to correct the deformity.

Exercises by means of Apparatus.—A remarkable and somewhat incomprehensible diversity of practice exists in this respect in different countries. On the Continent, and especially amongst the followers of Schulthess, the use of mechanical appliances for active and passive exercises, and for intermittent correction, is widespread. This is less so in France, and least so in the English-speaking countries. In London, undoubtedly, this branch of orthopaedic therapy has been neglected in the past—a state of affairs requiring reconsideration. It must be remembered, in extenuation, if such is necessary, that the practice of a speciality is to a certain extent biased by the general consensus of non-specialised surgical opinion; and in England the refusal to submit to fads and systems may have at times stood in the way of genuine progress. Then, the utilisation of expensive, highly complex, and numerous appliances requiring constant skilled supervision can only be practicable in some form of "Institute;" and the "Institute" conducted for gain is an idea to which we are averse. It has been said that there is no instrument like the human hand —perhaps so—but there is no instrument that tires like the human hand. Then, as to accuracy—the mere term, "with mechanical precision" indicates the superiority of apparatus. In any case we are bound to accept, that intermittent correction worthy of the name is frankly impossible except by mechanical means. Of all possible means of attacking scoliosis we can conceive of nothing more valuable than the performance of active exercises by the patient, whilst mechanically forced into the corrected or over-corrected position. We do not say that they are reasonable or suitable for every case, but just as a varus may be cured by being made to functionate in a position of valgus, so might a scoliosis be cured if it were possible to force the spine to functionate in an

over-corrected position. Unfortunately it is not completely possible, but by means of machines it is more nearly so than by other methods.

The utilisation of mechanical appliances for the treatment of scoliosis has been brought to a very high pitch by Schulthess of Zurich. In Joachimstal's *Handbuch*, 5. Lieferung, pp. 1104 to 1153, he describes and illustrates nine machines of his own, and three others, by means of which all varieties of curvatures can be attacked. We refrain from illustrating them here, because an installation of this character is so expensive that it can only be of interest to a very special clinic. A few remarks, however, may not be out of place.

Schulthess' body-bending apparatus No. 1 is very useful for dorsal curves; the patient flexes the body laterally in the direction of increase of the dorsal curve. In doing this she raises a weighted pendulum. The pendulum swings to the opposite position, and thus she passively corrects or over-corrects the dorsal curve. The position of the shoulders can be influenced, and pressure brought to bear on the rib-prominence at the same time. Also, modifications can be introduced by arranging the pendulum asymmetrically to the body stem. In this appliance the shoulders are fixed to a cross-bar screwed to the pendulum shaft, so that the body moves with the pendulum whilst the pelvis is fixed.

In another appliance the pelvis and lower extremities move with the pendulum, the shoulders being fixed by the patient grasping overhead horizontal bars, or by means of a shoulder strap; or the mobilisation of the lumbar curve may be combined with active shoulder-raising exercises calculated for active redression.

Exercises are prescribed for ten minutes several times a day. At each *séance* about 300 double oscillations are carried out.

In the "Schulterschiebeapparat" the pelvis is fixed, the spine moderately stretched by head extension, and (*a*) the patient laterally pushes with the shoulder against a pad, thereby raising a weight, or (*b*) the shoulder pad is fixed, and the patient has to raise a weight by laterally displacing a pad resting against the side of the thorax. It is clear that if the pad is resting in the concavity of a dorsal curve, in order to raise the weight the patient must actively reverse this curve.

The body-bending apparatus, No. 2,—still on the pendulum principle,—but in which the patient performs antero-posterior movements, is very useful for kypho-scoliosis.

He has further an appliance for directly combating rotation; and based on the observations of Delpèche, Fischer, Spitzy, Klapp, and Lovett on the effects of the horizontal versus the vertical position, he has devised an appliance for exercises in the prone posture.

We are quite aware that such extremely brief mention of

Schulthess' valuable appliances can be of little practical value save

FIG. 365.—A patient with Left Lumbar Scoliosis, prepared for treatment by Lange's method and apparatus (Lange).

FIG. 366.—Lange's Method of treating Left Lumbar Scoliosis, which is *actively* converted temporarily into a Right Lumbar Scoliosis (Lange).

as indicating the lines on which scoliosis is being attacked; and we

feel that at present it is more advisable to call attention in detail to less costly and complicated apparatus—such as that devised by Lange—so that, as he remarks, the treatment of scoliosis may not be

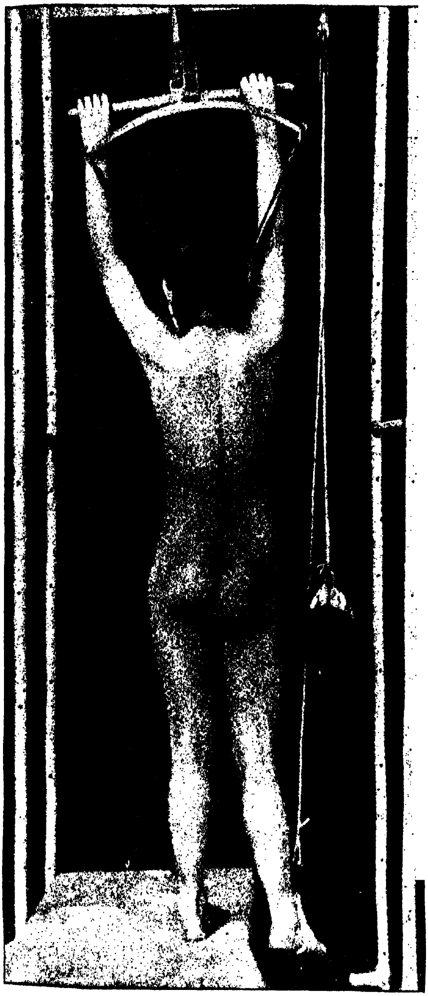

FIG. 367.—Correction of Left Lumbar and Right Dorsal Scoliosis; see text (Lange).

FIG. 368.—Another method of Correcting Right Dorsal and Left Lumbar Scoliosis; for explanation see text (Lange).

the monopoly of the well-to-do. Lange's idea is to utilise simple and inexpensive appliances, such as can be prepared anywhere, for both active and passive over-correction.

For example:—

i. A left lumbar scoliosis may be **actively** over-corrected into a right by the patient standing with the left foot on a block, and raising a weight by pressing down a stirrup with the right foot. The hands grasp rings above the head (Fig. 366).

If a right dorsal, left lumbar is present, care must be taken that the dorsal curve is not adversely influenced. To prevent this, it is the left hand which grasps a ring above the head. Or, the same effect is obtained by suspending the head in a Sayre's sling during the exercise (Fig. 367).

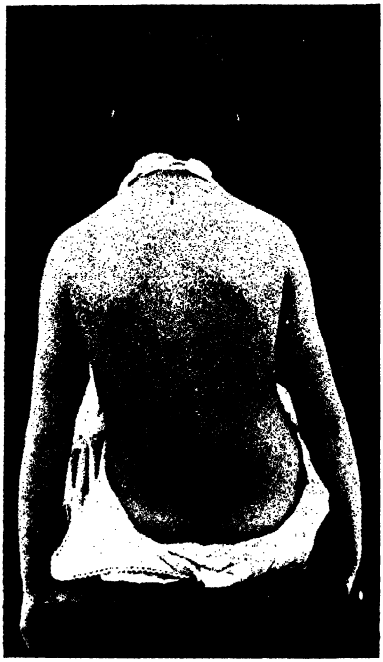

FIG. 369.—A Left Total Scoliosis, suitable for Lange's Method of Treatment, shown, over-corrected, in the next figure (Lange).

Or, whilst exercising, the dorsal curve may be held more or less corrected by a carefully modelled wire and celluloid shoulder-ring, kept tightly in place by a strap round the opposite ribs (Fig. 368).[1]

ii. A left total curve may be actively corrected into a right by the patient displacing to the right a pad resting in the right loin, and in so doing raising a weight (Fig. 370).

iii. A total scoliosis, in which the shoulders are fairly level, may, after treatment, show the shoulder on the originally convex side, standing too low. To obviate this, active shoulder-raising exercises are performed,

[1] *Zeitschr. f. orth. Chir.* Bd. xviii. Hefte 1 and 2.

whilst the spine is held forcibly over-corrected. Lange secures this in the way illustrated in Fig. 371. Pressure is exerted on the **convexity** of the curve by means of a belt and pad, and counter-pressure on the pelvis and base of neck, thus reversing a total left into a right. The patient is seated on an oblique seat. The pad on the ribs is arranged to

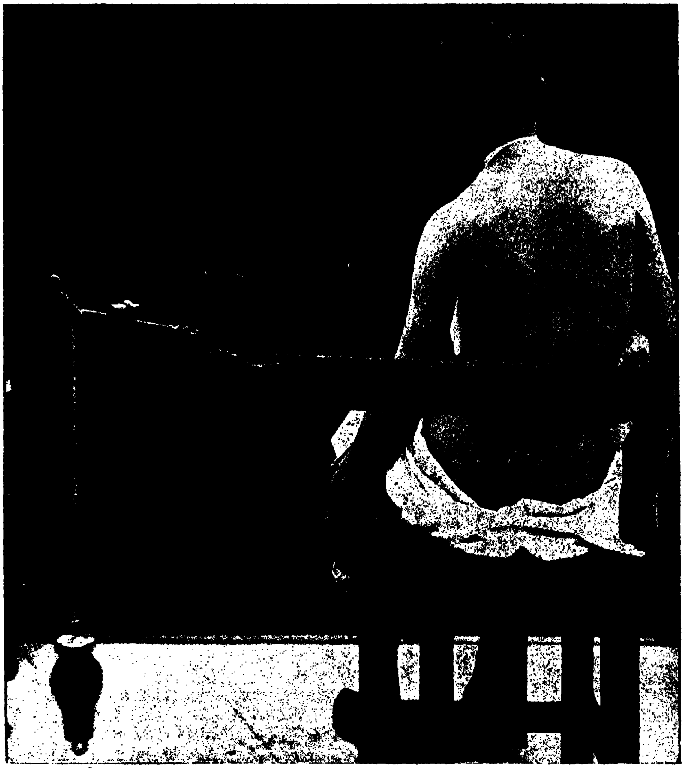

FIG. 370.—Active Correction of a Left Total Scoliosis. For explanation see text (Lange).

give rise to detorsion. The active exercise is carried out by raising a weight with the left hand.

iv. To take the case of a right dorsal, left lumbar curve. Lange passively corrects the lumbar curve by the oblique seat, pressure and counter-pressure; then he actively over-corrects the dorsal curve by making the patient raise a weight by pushing up the left shoulder. This is done by contraction of the right erectors of the spine and of the left shoulder raising muscles (Figs. 372, 373, 374).

v. A simple apparatus for active detorsion (Figs. 375, 376), by which

the patient, with pelvis fixed, raises a weight by actively rotating backwards the sunken ribs against pressure.

vi. An appliance for strengthening the back muscles. In this the patient raises a weight by extending the spine against the pressure of a neck-sling (Fig. 377).

Lange also employs means of a somewhat similar nature for

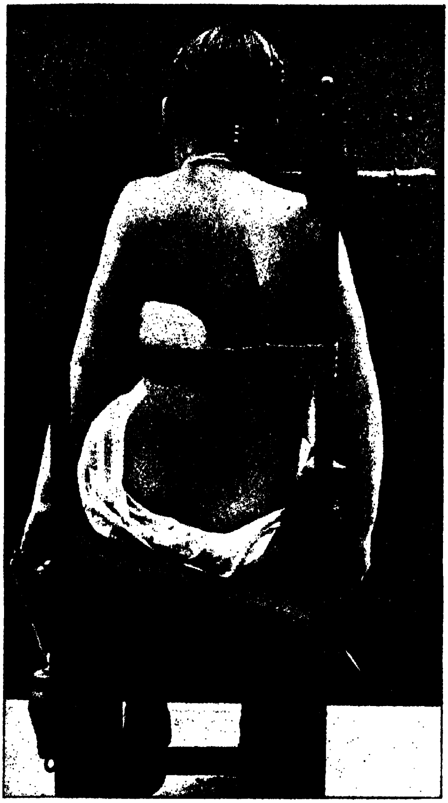

FIG. 371.—A Left Total Scoliosis, with the shoulder too low on the left or convex side, being treated for inequality of the height of the shoulders. The curvature is over-corrected (Lange).

periods of passive over-correction. It is true that in several of the above exercises passive over-correction is effected, but it is in conjunction with active exercises (cf. Exercise IV. p. 507), and like all active exercises for scoliosis can only be employed for brief periods on account of the fatigue produced. It is possible, however, to

submit a patient to passive over-correction[1] for a matter of some hours daily.

vii. The patient lies prone on a padded board, which has lateral rails for the attachment of belts or straps and the fixation blocks. For example, we take the case of a right dorsal, left lumbar scoliosis to be over-corrected into a left dorsal, right lumbar.[2] The patient is fixed by the padded blocks clamped to the frame, then the body belts are pulled taut until the desired correction is attained. And one further point must

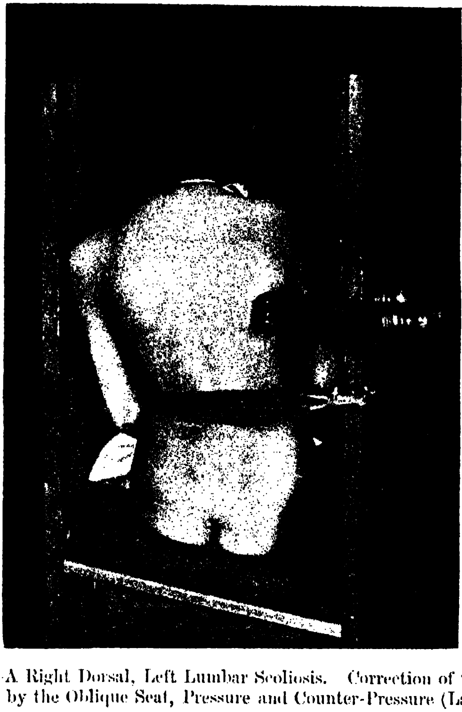

FIG. 372.—A Right Dorsal, Left Lumbar Scoliosis. Correction of the Lumbar Curve by the Oblique Seat, Pressure and Counter-Pressure (Lange).

be considered. It is possible that the direct lateral pull of the body belt might increase rather than diminish torsion. To obviate this, the laterally displacing body belt (Figs. 378, 379) is supplemented by a detorting belt

[1] Of course it must be clearly borne in mind that when we speak of exercises for over-correction in cases of even moderate severity, we mean exercises **tending** to over-correct. Actual over-correction, for example, the conversion of a right rotation into a left rotation, is, save under certain exceptional conditions, inconceivable. Possibly, in a slight case very prolonged treatment in the direction of over-correction might, in fact, reverse or over-correct the curve.

[2] Cf. also Figs. 378, 379, p. 514.

as in Fig. 380, the action of which is clear from Fig. 381. Lange increases its effect by interposing a suitable cushion or pad between it and the rib-prominences, and by increasing the resistance under the prominent half of the chest in front.

viii. For use at night Lange prefers in place of the Lorenz plaster bed one fashioned out of celluloid and metal. A plaster cast is made of the patient's trunk. This is corrected by shaving down the rotatory prominences, and adding fresh plaster to the concave regions, and shaping. On

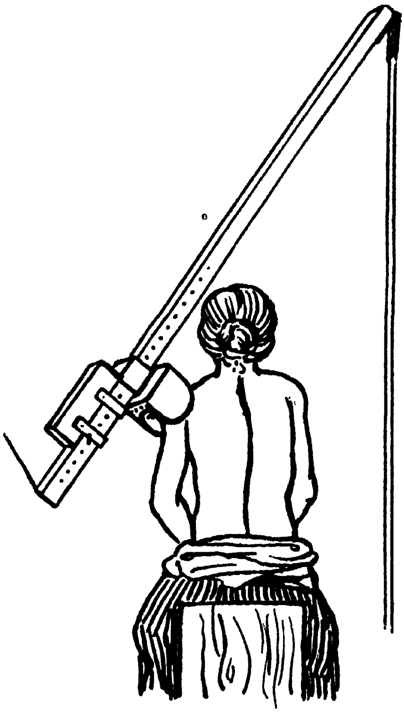

FIG. 373.—A right dorsal and left lumbar curve. Position and Apparatus for raising the left shoulder, so as to correct the right dorsal curve (Lange).

the model thus corrected an "ectoderm" is fashioned. This is composed of tow soaked in celluloid, dissolved in acetone. It is strengthened by metal strips, and finally upholstered. It is much lighter than the Lorenz plaster bed, and whilst more corrective is less restrictive, since the patient can shift somewhat, and yet cannot get away from the appliance (Fig. 382).

In many instances the Zander apparatus is of service. The great objection to it is the cost.

Active Exercises.—Their importance cannot be exaggerated.

The maintenance of the equilibrium and the shape of the spine is a matter of muscular action and co-ordination, and whatever temporary measures are adopted to straighten the spine, in the long run we must rely solely on muscular action to keep it straight, save in a few cases, as for example those severe ones due to infantile paralysis, where permanent support is often essential. In scoliosis the back muscles must be developed more than in the

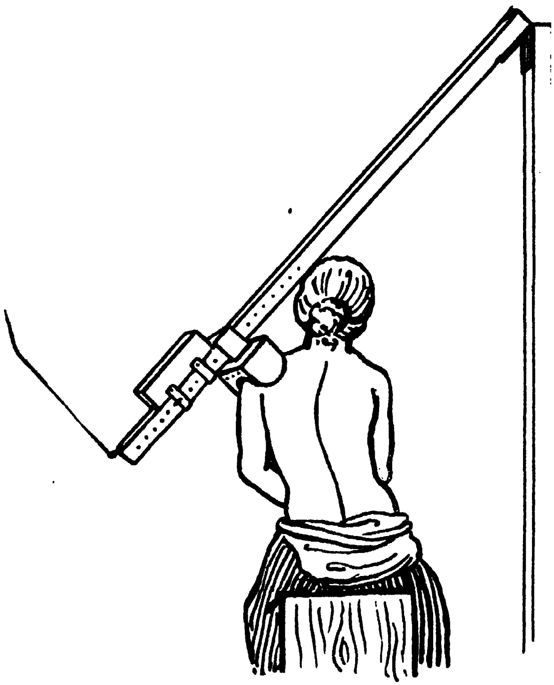

FIG. 374.—The Correction of the right dorsal curve, and Temporary Transformation into a left dorsal curve, by raising a Weight on the Left Shoulder (Lange).

normal subject, since more muscular effort is required to control a curved spine. That is, the muscles attached to a scoliotic spine are handicapped, and must be reinforced accordingly. Further, attention must not only be limited to exercises calculated to develop the back, and overcome the deformity, but general muscular development is essential, since errors of deportment and vicious positions are as a rule traceable to fatigue.

Another point is that muscular, osseous, and ligamentous

development take place *pari passu*, as is shown by the study of the bones of persons following occupations entailing great exertion.

In carrying out exercises the trunk is bared, so that the effect of each may be noted. The heart and lungs should be carefully examined. The patient's weight is ascertained each week; if it is found to be diminishing, then the exercises must be either moderated

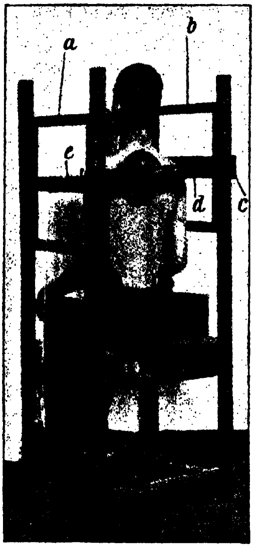

Fig. 375. -A simple apparatus for Detorsion. For explanation, see text (Lange).

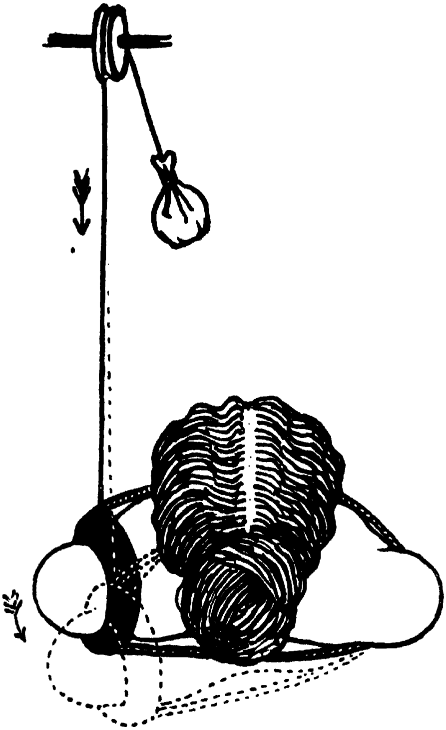

Fig. 376. -Another method of Active Detorsion (Lange).

or discontinued, or else some other cause, such as over-fatigue, due to school work or otherwise, be remedied. In girls, exercises may need modification during menstruation. If it is found that a patient remains fatigued after the exercises, or becomes anæmic and listless, or is troubled by menorrhagia, the whole position should be reconsidered, and in such cases it may be advisable to diminish the amount of gymnastic work.

The duration of the exercises varies from a quarter to half an hour in weakly patients, up to one hour or even two hours a day

in the vigorous, and according to the strenuousness of the efforts involved.

Active exercises should always be followed by a period of recumbency in the corrected position, lasting for an hour or more, on the lines already laid down (see Lange's method vii.). They will require to be continued under personal supervision for some weeks

FIG. 377.—Apparatus and Exercise for strengthening the Muscles of the Back (Lange).

or months, and after this can be carried out at home. But, it is not safe to do without skilled supervision until the growing period is past.

Fixation of Pelvis.—Whether the patient is standing or sitting it is essential in certain exercises that the pelvis should be fixed. A simple form of apparatus consists of a good-sized wooden platform, to which is fixed a strong vertical upright, and on this slides a horizontal arm carrying two wooden clamps capable of lateral

adjustment. Straps may be added, passing round the patient from one clamp to the other if necessary.

SUPPORTS

Spinal supports have but a small place in the *corrective* treatment of lateral curvature, and are to be regarded as a means of retaining the gain secured by other methods in some particular instances, and of

FIG. 378.—Position and apparatus for correction of right dorsal, left lumbar scoliosis (Lange).

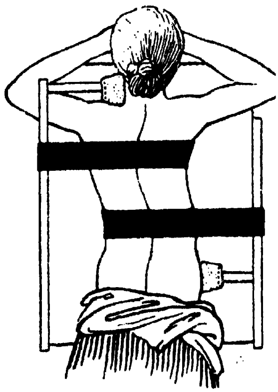

FIG. 379.—Diagram of the effect of the apparatus, when used as in Fig. 378 (Lange).

affording passive assistance in the intervals between exercises. Supports fail, if relied on alone, because they have little corrective value. Starting with a spine which has lost some of its flexibility, they render it less flexible still. They cannot correct it any further, on account of the mechanical disadvantage under which they work. The area from which leverage can be exerted is too small, and pressure is often badly borne. Every spinal support must start from a fixed base, and the only place of fixation is round the pelvis, between the trochanters and crest of the ilium. Even if what is known in this country as Ernst's apparatus is used, where additional bands of steel pass above the crests of the ilium, the area of the base of support

is not always sufficient to withstand the lateral thrust of the

FIG. 380.—The "Detorting" Body-Belt (Lange).

displaced trunk. Supports are not to be used in cases of early

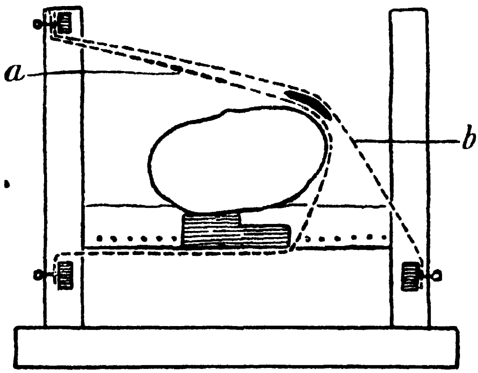

FIG. 381.—Diagram to illustrate the Action of the "Detorting" Body-Belt (Lange). This refers to a condition of curvature the reverse of that in Fig. 380.

total scoliosis, or in cases of slight organic scoliosis, except for weak, weedy patients who collapse between the *redressements*. They

are not to be fitted to any form of scoliosis if the improvement

FIG. 382.—Lange's Ectoderm of Celluloid.[1]

obtained by the exercises is maintained in the intervals. Nor should they be used in old-standing structural cases, which have long been quiescent.

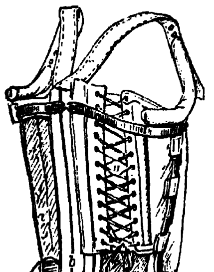

FIG. 383.—Adams' Spinal Support. *aa'* Spring Plates and Laced Shields, *b* Vertical Back Lever.

In cervical or cervico-dorsal curves the ordinary form of support is useless, unless an occipital head-piece is added. This is rarely tolerated, and even then, a support, by preventing compensation lower down, may be positively harmful. A spinal apparatus, however, should be used where destruction of the muscle has taken place, as in infantile paralysis.

With these cautions as to the use of supports a word or two of description of those most commonly in use may be associated.

The Spinal Support (Fig. 383), with its spring plates and laced shields, designed by William Adams, has proved of great value

[1] We do not approve of celluloid corsets, on account of the danger arising from fire.

in certain cases in which the patient is not improved by exercises, or is unable to maintain the improvement in the intervals between the redressments. One *spring* plate and shield *a* act upon the prominence of the ribs, and the other laced shield and plate *a'* afford the necessary counter-pressure in the loin. When sufficient response is made to the exercises, the use of the support may be discontinued or lessened. The apparatus in appropriate cases has given good results in the author's practice. It is light, weighing about one and three quarter pounds, simple in construction, and does not require frequent visits to the surgeon, as the adjustment can be performed by any person of intelligence after the mechanism has been explained to them. The apparatus fits closely to the pelvis, and a vertical back lever *b*, acting on the trunk through the axillary *crutches*, maintains it in extension. The effects of the spring plates and of tightening the laced shields are to produce a detorsion force, acting in the reverse direction to the torsion of the deformity.

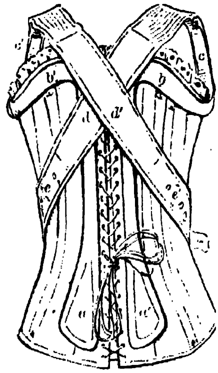

FIG. 384.—Adams' Spinal Stays. *aa'*, Steel Bands on either Side of the Median Line posteriorly, continued round the body laterally, and terminating in Axillary Crutches, *cc'*. To the ends of the latter, shoulder-straps *dd'* are attached, the length of which can be regulated at *ee'*.

A simple support and an efficient reminder of the necessity of assuming the corrected position is found in the spinal stays (Fig. 384) designed by William Adams.

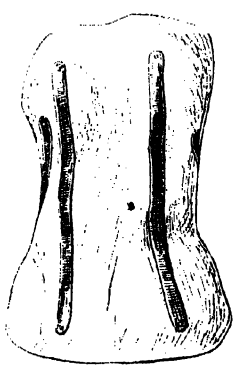

FIG. 385.—A Poroplastic spinal-jacket, strengthened by steel-supports, for Intractable and Painful Cases of Scoliosis.

In advanced stages of scoliosis, when the patient suffers from pain and visceral displacement, some form of support is necessary. Such conditions are sometimes met with after parturition in a patient, who has been the subject of spinal curvature from youth. A useful support in such cases is the poroplastic jacket, particularly if it is strengthened by vertical steel bands moulded to the outline of the figure (Fig. 385). The plaster of Paris corset, put on after the method of Sayre, gave rise to great expectations in the treatment of scoliosis, but everywhere the same experience has been met with. Patients who have worn them for

months or even weeks, after their removal have a straightened back, it is true, but when they discard them there is risk of increased deformity. Nevertheless, the plaster of Paris corset was a great step forward on account of the attempts which were made at redressment, with subsequent fixation. Generally speaking, the results of corset treatment, if carried out to the exclusion of other methods, are most unsatisfactory. Without exercises and massage, and with neglect of the muscles, atrophy of them and of the subcutaneous fat, and perhaps of bone, ensues; and, after their removal patients hold themselves worse than ever. With much reluctance the advocates of corsets are forced to admit this fact. To-day corsets are only used for temporary fixation in the corrected position, and temporarily during treatment.

Space does not permit us to describe other forms of corset, the patterns of which are legion.

In considering the value and potentialities of any particular form of corset, we must bear in mind whether it is designed to be—

i. Simply supporting.

ii. Corrective, and in this case is it

(*a*) Removable?

(*b*) Irremovable?

i. A corset, simply supporting, such as a well-made pair of stays, may be of great value to a patient who is compelled to follow a sedentary occupation, and is unable to give much time to more curative or rational treatment. Such a support must be light, fairly rigid, not unsightly, and comfortable in the sitting posture.

A different support is needed for severe and progressing cases. Here strength without undue weight is the desideratum.

ii. The corrective and removable support we have already dealt with, and experience derived from redressment and fixation in plaster of Paris teaches us that the permanent effect of the so-called corrective appliances is slight. They are in reality splints.

Suspension.—In patients with fairly developed muscles and non-rigid spines, suspension for a few minutes daily from a horizontal bar is of service. It should not be employed in weakly people with long willowy backs; as, on account of the fatigue caused, the back collapses immediately the patient ceases to hang by the hands.

Rapid Correction

It is quite certain that in scoliosis an appreciable elongation of the spine is obtained by stretching out the less fixed curves. And if sufficient force is used a very considerable straightening results. Wullstein has demonstrated this fact clearly by straightening out the curves in the scoliotic cadaver, by means of the same appliances which he uses for actual treatment.[1] He noted that under this forcible extension very marked changes are observable in the intervertebral discs of the curved segment of the spine. Before stretching, they are compressed on the concavity and expanded on the convexity. During extension they elongate two or three times their previous depth on the concavity, and become compressed on the convexity. Thus, not only is the spine partially straightened, but some of the structural changes disappear.

Lovett maintains that stretching by means of head-extension and fixation of the pelvis is not the most effective way of reducing curvature. He points out that no one attempts to straighten a bent rod by pulling the ends away from each other. If we wish to straighten the stick we bend it over our knees, that is, we apply a "cross-breaking strain." The amount of force which must be used to straighten a bent stick by pulling the two ends is very much greater than that used in bending it against the knee. In a very yielding spine suspension will straighten it materially, but it has comparatively little effect upon a badly bent spine. What is required in these cases is first of all to get the spine as slack as possible, and then apply the corrective force laterally.

Lovett, therefore, dispenses with traction, and attempts to straighten the spine by placing the patient in the prone position with the thighs bent at more than a right angle (to do away with the lumbar lordosis), and then applies the corrective force laterally.

The prone method, however, does not "slack" a fixed scoliotic curve. And if the spine is not *fixed*, Lovett's argument hardly holds, since we do not straighten a kinked *flexible* wire across the knee, we pull it straight. Besides, if extension is used, that does not imply that direct lateral pressure is dispensed with. In practice both are used. Then rapid correction is only a preliminary to the application of the plaster jacket, and surely it is wiser to apply the jacket with a view to the comfort of the patient when she stands erect afterwards. Lovett[2] says: "Corrective

[1] Joachimstal, *Handbuch f. orth. Chir.* 5. Lief. fig. p. 1055.

[2] *Lat. Curv. of the Spine*, p. 153.

jackets should be applied to the patients prone, and preferably with the legs flexed, as this diminishes the physiological curves of the spine, and further simplifies the problem." We cannot see that simplification in the way of obliteration of the normal physiological curve is simplification at all, unless Nature's curves are an error. But the strange point is that other surgeons deem it necessary to preserve carefully the very lordosis that Lovett endeavours to neutralise, because they find that unless this is done, the patient cannot possibly wear the jacket owing to the distress caused thereby.

The author can see no reason to sacrifice the direct pull on the spine, obtained by suspension, to the indirect application of force to the spine by pressure on the pelvis and ribs. There is no great objection to the prone position, *per se* it is the best, but we fail to perceive the necessity for flexion of the thighs, and we believe that traction is essential to minimise the deformity. At all events we know of no demonstration of correction so thorough as that obtained by Wullstein.

As to the whole question of rapid correction followed by the plaster jacket, it is possible that the outlook in scoliosis would be better if such radical means were adopted earlier in many cases. And it is probable that the tendency in future will be to fix the spine by successive redressments in the best possible position from the first, and then develop the musculature subsequently. We ought not to permit scoliosis to run on to a more or less severe degree whilst trying milder measures. It is not, however, suggested that all or even the bulk of cases are suitable for, or need this method. And it must be remembered that the successful application of plaster jackets for scoliosis in these special ways calls for care and experience. Many considerations have led to the recent revival of this method. Three may be mentioned.

The outcome of experience gained in Calot's method of treating Potts' disease naturally suggested the idea of rapid correction and fixation on somewhat similar lines in scoliosis. Next, the wider acceptance of Wolff's views, that if the parts could be partly replaced and made to functionate in a more normal position, adaptation of the osseous and other structures might be anticipated. Lastly, unfortunately, many cases do not react well to other methods of treatment, and in old-standing fixed cases little improvement has hitherto been obtained by them.

Against the method it is strongly urged that atrophy of the muscles results from fixation. Still, it must be remembered that a plaster shell, however tightly applied, can never be so closely adapted as completely to eliminate the functions of the spine, and the muscles can be redeveloped.

In early rachitic cases, in congenital scoliosis, in certain rapidly progressive cases, and in the preliminary correction of cases not amenable to other methods, for example paralytic cases, this method has an obvious place. It is in the attempt, however, to obtain actual improvement in old-standing fixed cases, and the possibility of its early application in slighter ones, that the great interest of this method of redressment and fixation in plaster of Paris lies.

The method is by no means new. Since Sayre introduced his plaster bandage, of such undoubted use in caries of the spine, surgeons have been tempted again and again to utilise it in the treatment of scoliosis. In fact, after the experience of the older orthopædists, there could be no excuse for reviving the practice, except for certain definite improvements in technique. These are the more thorough correction of the spine, and the temporary use of the jacket, followed by careful and energetic after-treatment so as to strengthen the muscles. The modifications and details necessary to obtain the best results have been thoroughly worked out by Wullstein. It is hardly correct to speak of a Wullstein method, since, as we have said, the application of a plaster jacket whilst a patient is suspended is an old practice. Still, to him must be assigned the credit of introducing so many improvements that the whole procedure becomes radically altered.

He seats the patient on a stool composed of independent halves, so that one tuber ischii can be raised higher than the other, and the pelvis tilted.

Further, the seat is not level from front to back but sloping, the object being to maintain the lumbar lordosis whilst the jacket is being applied. When we sit on the ordinary level seat the thighs are flexed at right angles with the trunk, and the lumbar lordosis is more or less flattened out, or even replaced by kyphosis. According to Wullstein, a jacket applied with the spine in such a position becomes intolerable to the patient when the sitting posture is changed to the standing one. In other words, a jacket applied with the lumbar spine in kyphosis cannot be borne by the patient in the erect posture, because in the erect posture lumbar lordosis is essential. By sloping the seat, then, so that it is higher behind and lower in front, the thighs are only partially flexed and lordosis in the lumbar region maintained. It might occur to the reader to do away with the seat altogether, but in the Wullstein method the seating arrangements are really part of a very efficient pelvic fixation, the patient's thighs being strapped down to the seat.[1] With the pelvis thus fixed, and the head suspended[2] by chin and occipital straps, the spine can be

[1] See fig. 859, p. 105, Joachimstal, *Handbuch f. orth. Chir.* 5. Lieferung.

[2] See figs. 863, 864, *ibid.*

elongated and straightened, the amount of the pull being registered by a manometer. The force used varies from 50 to 125 kilogrammes.

Rotation is overcome by direct pressure, where required, *e.g.* on the lower ribs. This is done by means of adjustable arms with pads clamped to the frame of the apparatus. The pads are left incorporated in the plaster corset. Further, means are provided[1] for controlling the position of the patient's arms and shoulders.

In short the spine is stretched, elongated, untwisted, and corrected forcibly in every possible way; and this is done with the patient in the sitting position.

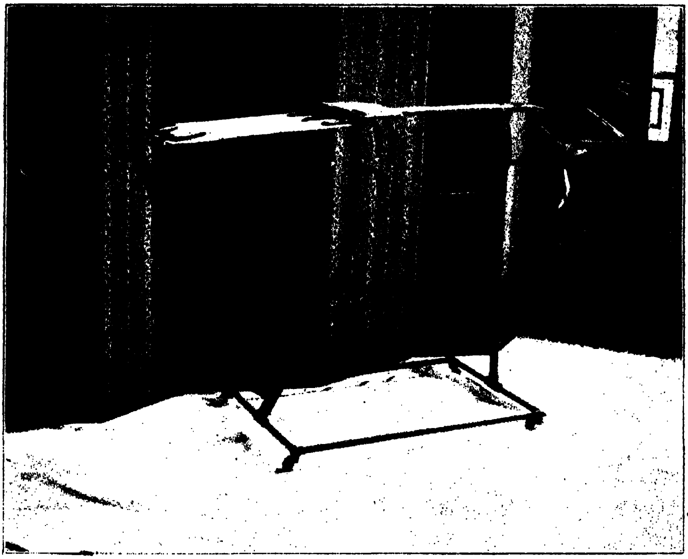

FIG. 386.—The Author's Portable Frame, used in the Rapid Redressment of Scoliosis. On the right is seen the head and neck sling, on the left the metal counter-extension for the legs and feet, and between them the strips of canvas.

A very stout plaster of Paris bandage is applied, including the head. Later the skull-cap portion is cut away, and large apertures are made over the stomach and the sunken rib region to allow expansion during respiration. The bandage may be worn eight to ten days, then a second correction made for further improvement. The total duration of wearing plaster varies from weeks to months.

The application of a definitely constricting plaster bandage is not free from risk. Both Lange and Wullstein have proved the wisdom of keeping a sharp scalpel handy, having had quickly to slit up the bandage and resort to artificial respiration. Lange is so

[1] Fig. 864, p. 1061, Joachimstal, 5. Lief.

impressed by the dangers of the method, and by its disadvantages, that he has quite given it up. Schulthess has had no personal experience of it. It is useful in certain cases, and it is to be treated as a serious surgical procedure. The immediate gain in length and symmetry is undoubted; whether the gain can be kept up is still *sub judice*. Still, as we have hinted, the question really is whether a much earlier resort to this method would not be of value.

As to Lovett's method, the application while the patient is prone with the thighs flexed and the lumbar lordosis abolished, we

FIG. 387.—The patient is fixed in the Frame in the Prone and Extended Positions. The lumbar curve is corrected by tilting the pelvis, and putting more extension on the leg and foot of the concave side, and plaster of Paris is being applied to the trunk.

have no personal experience. We have already given reasons why we do not think this plan is likely to be successful. The author certainly has used the prone position, but with the thighs extended and with traction and counter-traction—a procedure which has nothing in common with Lovett's. It is much more like Wullstein's, save that the pelvis is not inclined at all, and it is less arduous to the patient. This method is as follows:—

The author's method of spinal redressment in scoliosis: An iron frame (Fig. 386) is used, and is constructed so that it can be easily folded for transport. The patient lies prone upon two pieces of

stout canvas four inches wide, attached to the upper part of the frame by straps. Traction is applied to the spine by assistants or by head, arm, and leg straps. By varying the pull on either leg, as required, the pelvis is tilted, so as to obliterate entirely or partially the lumbar curve, while the general effect of extension is to lessen the dorsal curve. It is well to place a small pillow below the abdomen or a dinner-pad made of cotton wool is used. This not only answers the purpose indicated but also lessens

FIG. 388.—The Actual Moment and Method of correcting the Dorsal and Lumbar Curves, just before the under layers of plaster set. Strips of malleable iron are then moulded and laid on either flank so as to strengthen the jacket and prevent buckling. The strips should be so placed as to be out of the way of any window which may be cut in the plaster, when it has hardened.

lordosis. If the normal lumbar curve is increased, the patient complains very much of backache when the erect position is subsequently assumed. One or more assistants make pressure upon the ribs so as to overcome, as far as possible, the lateral deviation and rotation of the spine, and plaster of Paris bandages are then applied in the corrected position over a stockingette jersey; the bandages must go well down on the hips, and the pelvic part of the jacket should always be very strong; above, the jacket reaches as high as possible on the trunk (Figs. 387, 388). The strip of

stout canvas which supports the patient's body is then cut through. After the jacket has dried sufficiently, the patient is put into bed. Some discomfort is often experienced for the next twenty-four hours. If too much extension force has been used, troublesome vomiting ensues, but the author has been compelled to remove the jacket on one occasion only. On the second day after the application of the jacket, windows are cut over the ribs in the concave side of the dorsal curve, and the jacket is trimmed carefully at its edges. It is found that expansion of the "concave" ribs takes place if the

FIG. 389.—The Jacket complete. On the Concave Side of the Dorsal Curve a Window is cut to allow the Sunken Ribs to expand.

pressure of the jacket is removed from them, and this acts as a means of detorsion.

The jacket is left on from one to two months, and then another is applied if necessary. When it is evident that the maximum of benefit has been gained by this method of redressing, vigorous massage of spinal muscles with carefully graduated exercises is carried out. The patient should take long periods of rest daily, and if she is unable to retain the improved position in the intervals of exercises and massage, then a light steel support is fitted for temporary use.

The advantages of this method of redressing the spine are its simplicity and safety; the effects of extension of the spine, and of

pressure on the ribs can be seen, whilst the force used is always under control. Its disadvantages are the need of several assistants and the temporary shifting of their hands while the bandages are being put on. Still, practice overcomes the latter small difficulty. Fairly successful results have been obtained by this method (Figs. 390 to 397), and the author advocates that its adoption be not delayed until the deformity has become severe.

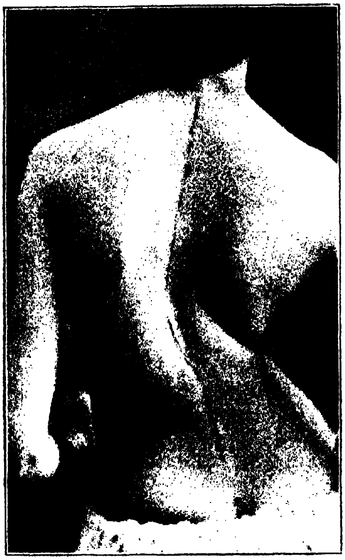

FIG. 390.—Photograph of the back of a female patient, aged 21, before treatment by the author's plaster method.

FIG. 391.—The same patient as in Fig. 390, after correction and the application of four plaster jackets.

Another method, but certainly not so effectual, of rapid *redressement*, is described by Chipault.[1] In this method no direct attempt is made to overcome rotation, but he argues that it is less important than one might suppose, since lateral deviation cannot be affected without rotation being also influenced. In the author's method, both lateral deviation and rotation are lessened by manual pressure.

[1] *Manuel d'orth. vertébrale*, 1904, pp. 156 and 157.

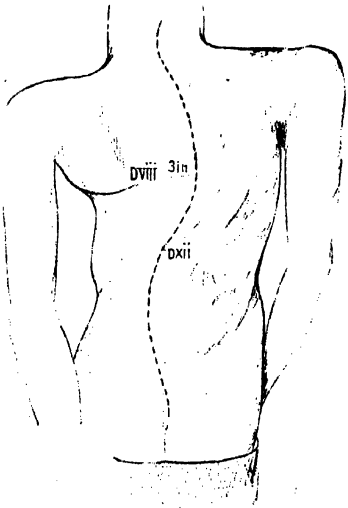

FIG. 392.

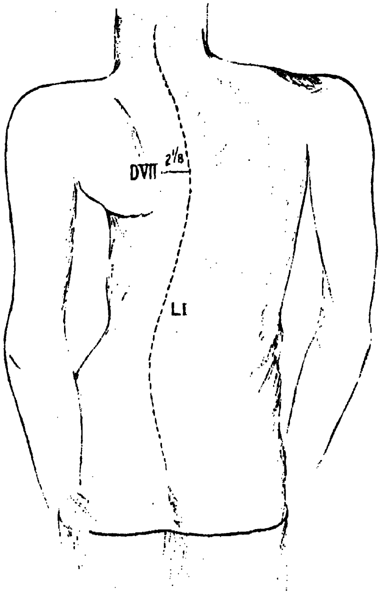

FIG. 393.

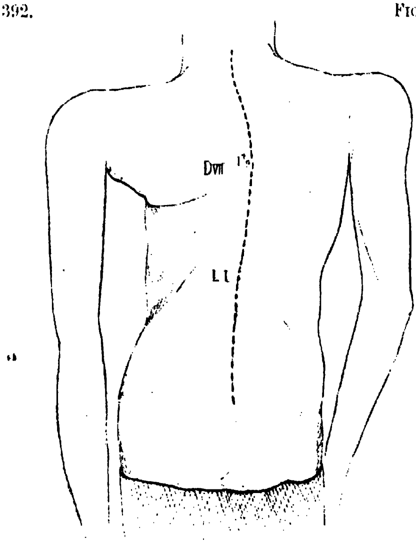

FIG. 394.

Three tracings from the back of a female patient, aged 30 years, after Five Corrections and Plaster Jackets. The maximum deviation of the dorsal spine has been reduced from 3 inches to $1\frac{3}{4}$ inches, and the lumbar scoliosis is nearly obliterated.

Lovett states that the most favourable cases for forcible correction are curves affecting the lower dorsal and dorso-lumbar regions. Lumbar curves are not accessible to side pressure on account of the absence of ribs, while upper dorsal curves cannot be influenced because the axillæ prevent a sufficiently high counter-point being taken.

Care should be taken in selecting the cases, especially in hospital practice; and before the treatment is commenced the importance of following out the necessary after-treatment should be fully explained to and appreciated by the patient, and she should be prepared to place herself under supervision for a period of one to two years.

Are the Results Permanent?—This, of course, is a question which only extended experience can answer. But, as Lovett points out, "the grounds that lead one to suppose that retention of the growing spine in a correct position for a sufficient period will lead to a change in the shape of the bones and to a permanently improved position are as follows:—(1) Club-foot may be cured by a similar proceeding; (2) The bones of the feet of some Chinese women become seriously mis-shapen by retention in an unnatural position; (3) Wullstein produced bony changes in dogs by a few months of an abnormal position; (4) The researches of Arbuthnot Lane on the changes in shape of the bony skeleton of labourers resulting from the habitual position of the load; (5) The remarkable changes which the lower jaw undergoes when, in Pott's disease, the head is supported by a chin lever."

That the spine can be straightened by this forcible method—and perhaps it is a misnomer to use the term forcible, since the patient experiences little or no inconvenience—can be demonstrated by repeated X-ray photographs taken in similar positions and from like points of view.

Schanz[1] states that there is no doubt that by a careful selection of cases and a correct carrying through of the necessary measures, one can retain the results of rapid correction of scoliosis permanently, and this agrees with our experience during the last three years.

Correction by Open Operation.—The author has had no experience in this direction. Operations have been devised by Volkmann,[2] which consisted of resection of the ribs on the concave

[1] *Verhandl. d. deutsch. Gesell. f. orth. Chir. Kongress*, iv. 61.
[2] *Berlin. klin. Wochenschr.*, 1889, l.

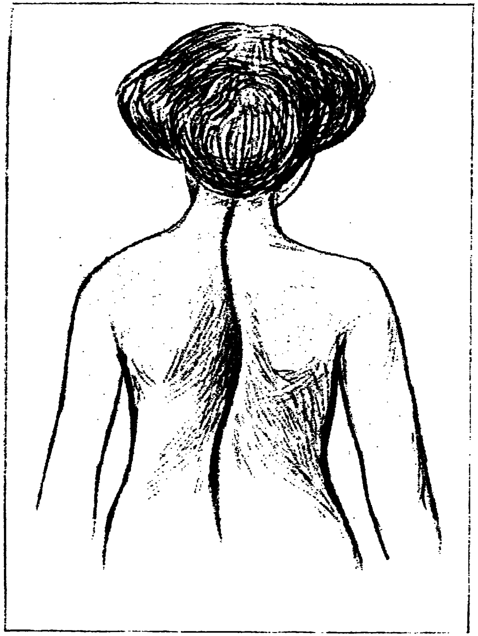

Fig. 395.

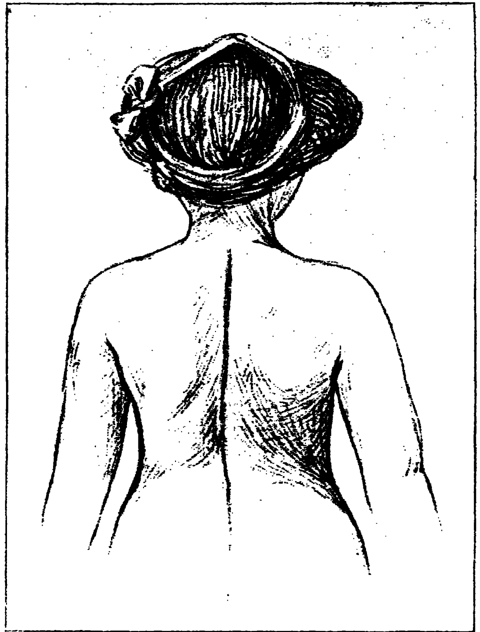

Fig. 396.

Outlines of the Spinous Processes before and after Two Corrections and Plaster Jackets. The back became practically normal. The patient was aged 18 years.

side of the curve. His suggestion was carried out by Casse[1] and Hoffa.[2] Hoke[3] performed a similar operation, and obtained a fair amount of apparent correction. Bade[4] also resected the ribs. Tenotomy and myotomy have long been abandoned. It should be

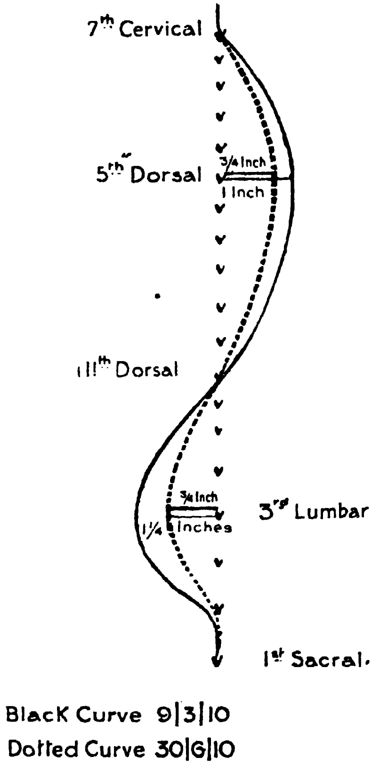

FIG. 397.—Tracings of Curves of the Back of K. C., aged 15 years. Before and after one correction and plaster jacket.

pointed out that anæsthesia in a case of bad scoliosis may be dangerous.

Resection of ribs has no detorsion effect on the spinal deformity and still further weakens the soft parts, and is therefore to be condemned.

[1] *Bull. de l'Acad. Royale de méd. de Belgique*, Dec. 30, 1893, Jan. 27, 1894.
[2] *Zeitschr. f. orth. Chir.*, 1896, 401.
[3] *Amer. Jour. of Orth. Surgery*, vol. i. p. 2.
[4] *Klin. Mitteil. und Centralbl. f. Chir.*, 1903, xxxviii. 1045.

CHAPTER VI

SCOLIOSIS OR LATERAL CURVATURE OF THE SPINE—*Contd.*

TREATMENT—*Continued*

The Treatment of Ætiological Forms—Treatment of Clinical Types—Gymnastics and Exercises—Selected Exercises—Manipulations

TREATMENT OF THE ÆTIOLOGICAL FORMS OF SCOLIOSIS

Congenital.—If the researches of Böhm are sound, we have often been treating, and with fair success, congenital scoliosis without recognising it. There is no particular reason why a wedge-shaped vertebra dependent on congenital causes should present greater obstacles to treatment than when the deformity is acquired. In the milder cases no departure from the principles of treatment already laid down is called for. In the severe cases much may be done by setting up an abrupt compensatory curve, as near the deformed vertebræ as possible. This is a principle that is applicable not only to congenital, but also to acquired cases. It is useless to attempt to attack directly a severe sharp structural bend, but, as Lange advocates, much may be done to neutralise it by inducing compensation. Schulthess also agrees that by keeping the primary curve short a good general outline of the whole trunk may be obtained.

Those cases, presumably due to intra-uterine malposition, and recognised at birth or soon after, can be successfully treated by postural methods.

In older children temporary fixation in plaster of Paris may be of great value, especially if applied with a view to the formation of compensatory curves. Many of the evil results in congenital scoliosis can be obviated by a recognition and rectification of the accompanying conditions, for example by removal of cervical ribs, and dividing the attachments of the scapula to the spine in

Sprengel's shoulder. Wedge-shaped vertebræ are naturally beyond the reach of surgery, although, as Perrone has suggested, possibly something may eventually be attempted in the case of unilateral sacralisation of the last lumbar vertebra.

Rickets.—It is comparatively rarely that a rachitic scoliosis is seen while the bones are yet soft; but at that time the treatment is obvious. The infant is to be placed recumbent in order to avoid the deforming effect of the body-weight. An appropriately modelled plaster or other form of orthopædic bed, with weight extension, is the best apparatus. The prophylaxis of rachitic scoliosis consists of an anti-rachitic régime and prompt treatment of the accompanying kyphosis. It is a good plan to carry children, under two years of age, affected with rickets in a wicker tray (Fig. 398).

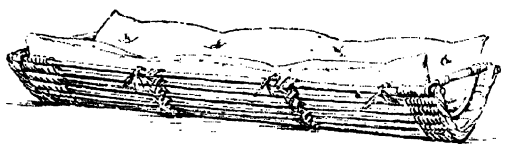

FIG. 398.—W. Adams' Spinal Tray used in treating Rachitic Kyphosis.

After the florid stage of rickets is passed, much may be done during the growing period by corrective exercises and by passive over-correction during the night. And in treating rickety spines one should constantly bear in mind that those exercises, which raise the tension of the longitudinal spinal muscles, have the same effect on the softened spine as increasing the body-weight. The latter factor is most productive of deformity in rickets.

When the deformity is severe, much may be done to improve the general shape of the trunk by encouraging compensation, as in congenital scoliosis. According to the predilection of the surgeon, forcible correction and plaster will be used; or else, mechanical correction on the lines advocated by Schulthess and Lange. The development of the muscles is all-essential. We have so often referred to this point that we need not labour it here, except to remark that in severe fixed cases it is so constantly neglected. Great improvement in the general carriage of those cases is obtained by appropriate exercises. Whatever methods are adopted the duration of treatment is very prolonged—years in fact.

Constitutional.—Underlying this form of scoliosis is a condition of skeletal inefficiency. We know, however, that an oblique pelvis may or may not be followed by scoliosis, the determining factor being presumably the yielding condition of the muscles, ligaments,

and bones. In treating these cases, therefore, we must take fully into account this weakness of the skeleton. It is foolish to overload by exercises a spine already sufficiently taxed by the ordinary daily routine. Exercises are of great value, but with certain restrictions. At first those performed in the recumbent posture should be selected, so as to obviate entirely the effect of the body-weight, and they should not be pushed to the point of fatigue, but sufficient intervals of rest and recumbency must be permitted. In speaking so cautiously we are alluding to incipient cases, where prognosis is notoriously difficult. In others, when observation and history show that no rapid change is going on, we may at once start on more energetic and corrective treatment. We do not think that Teschner's[1] heavy weight-lifting has a place in the treatment of scoliosis.

In the adolescent form, in its early stages at all events, exercises must be carefully graduated and their effects noted. If the curvature is increasing they must be regarded as unsuitable or excessive, and reliance must be placed more on passive over-correction, whilst the general weakness is combated by hygienic measures. We mean suitable food, fresh air, plenty of sunlight, baths, massage, change to the country or seaside, and tonics. Schulthess speaks well of phosphorus in these cases, although he says it is not so useful as in rickets. For our part we are by no means convinced of the efficacy of this drug as usually administered in bone-conditions. Possibly some of the modern so-called organic preparations may prove of more value, but for the present we prefer such medicaments as cod-liver oil and iron.

It is difficult in many cases to reconcile suitable treatment for this form of scoliosis with the conditions of school life. It may often be necessary to sacrifice school altogether in the interests of the child's physical development.

As to the nature of the exercises advised, it depends not only on the type, but on the stage of the curvature. Further, they must be modified according to the way in which the patient is occupied in the intervals. And in every instance exercises should be followed by a period of rest sufficient to neutralise any fatigue. Special care is called for in these cases, in order to prevent the patient lapsing into faulty positions in the intervals between the exercises.

[1] Teschner, *Trans. Am. Orth. Ass.* vol. ix.; *Ann. of Surg.*, Aug. 1895. If Teschner's views are correct, we have only to increase indefinitely the weight to be lifted to straighten out any curve—a proposition very difficult of acceptance.

The assumption of an habitually bad position in a constitutionally predisposed case leads to postural scoliosis.

This last remark leads us to the consideration of "*occupation*" scolioses. Unless they develop during the period of active growth they are rarely of grave importance. Thus, as we have seen, the effect of occupation in a growing girl may lead to severe deformity, whereas the nature of the calling seldom causes deformity in a well-developed adult. This is a different matter from the influence of occupation on a scoliotic patient; and it should be considered in every such case. As a general rule all sedentary callings which are likely to produce kyphosis are bad, *e.g.* the kinds followed by clerks and typewriters.

In Static Scoliosis the pelvic obliquity must be corrected. This is not always an easy matter, neither is it usually in itself curative. The scoliosis still remains to be attacked on the general principles already discussed. We may remark here that the intentional production of a pelvic obliquity as a method of treatment is useless. The patient simply compensates for the thick sole by flexion at the hip and knee. Volkmann's oblique seat (Fig. 364) has, however, a place in treatment.

Asymmetrical positions due to errors of refraction, torticollis, and other causes, require careful attention.

Paralytic scoliosis is not to be despaired of. Correction by extension and manual pressure followed by two or three weeks in plaster, may be employed in many cases. Light supports are often valuable, and an occipital head-piece is sometimes of distinct advantage. Schulthess has used a double crutch-support, allowing lateral bending towards the paralysed side, and when the patient attempts to bend towards the healthy side the appliance locks. This is a rational idea, for the paralysis is rarely complete; and, as the author has shown elsewhere,[1] if the paralysed muscles are guarded against stretching and encouraged to contract they show a marked tendency to recovery. Massage, electricity, and exercises are not to be neglected.

The treatment of **hysterical scoliosis** calls for no special comment here. **Ischias scoliotica** may be benefited by temporary fixation in the deformed position.

Cicatricial scoliosis, occurring after pleurisy and empyema, is not suitable for forcible correction on account of the condition of the lung. Careful treatment directed to expansion of the lung is

[1] *Surgery of Paralysis*, p. 50.

called for; and if the chest condition does not contra-indicate it, gentle passive mechanical correction of the spine may be tried.

Cicatrices are treated by division of the scar, by plastic operations, and by injections of thiosinamin.

Treatment of Clinical Types

TREATMENT OF "TOTAL" SCOLIOSIS

While total scoliosis is not necessarily an early or commencing scoliosis, still in a large proportion of cases it is so. For this reason, and on account of the relative simplicity of the problem, much satisfaction may be anticipated from treatment.[1]

In the very earliest, or called by some "functional" cases, there is no fixation, but merely a restriction of lateral flexion on the convex side. This is the clue to follow in selecting exercises. We advise the following:—

Repeated lateral flexion to the convex side, the pelvis being fixed; repeat this with patient recumbent as in Exercise X. (p. 552)—the convexity of the curve is to be uppermost so as to strengthen "actively" the muscles of this side. The patient may then reverse her position, and with the convex side undermost allow the body-weight to stretch passively the concave side. The trunk circling Exercises V. (p. 547) and XI. (p. 552) limited to the convex side are also useful; while Exercise I. (p. 545) and general setting up drill, although less specific, are indispensable.

It may be advisable to maintain passive over-correction for a time in the recumbent position during the intervals between the exercises. This may be very simply done by approximating the shoulder on the convex side to the corresponding hip. A leather band encircles the thigh; and another passes round the shoulder, the latter kept from slipping by being attached to a similar ring round the opposite shoulder, by means of a band across the back. The thigh-piece and the band on the shoulder of the convexity are connected by a strap which can be adjusted.[2] It is possible, but irksome, to carry out the idea in the sitting position.

Passive mechanical correction, on the lines advocated by Lange (pp. 506-510), may be tried, but it has the disadvantage in total cases of tending to create S-curves. This is also true of correction

[1] Schulthess claims that 87 to 96 per cent can be improved, including 8 per cent of cures.

[2] Joachimstal, *Handbuch f. orth. Chir.* 5. Lief. p. 1081.

in the prone position, as in Lovett's method. The risk of setting up contra-curves is less if suspension is used; although in strictly "constitutional" cases, suspension, if prolonged, stretches and weakens structures already enfeebled.[1] It is, moreover, rarely needed. As a rule, if severe structural changes are present, the type is usually no longer total.

The above remarks are fairly applicable, too, to moderate post-rachitic total scolioses. But whilst rachitic softening and the accompanying muscular condition are present, there is nothing better than slight over-correction in the plaster bed, with an arrangement added for extension of the head.[2] The general health is kept up by appropriate means.

Congenital total scoliosis should be rapidly corrected. In the intra-uterine malposition group the correction should be absolute. When maldevelopment of the vertebræ is present, correction aims at producing a sharp counter curve immediately above the vertebral anomaly, and retaining the improved position in plaster of Paris.

Lumbar Scoliosis

Lumbar scoliosis appears, as a rule, at a somewhat later age than the preceding forms, and the patients are generally girls of 14 or 15 years of age. Although structural changes of more or less extent have occurred, yet excessive or even very considerable deformity, except in a few rachitic cases, is quite exceptional, so that radical measures, such as rapid correction and fixation, are not called for. This is fortunate, since the lumbar region, owing to the absence of ribs and thickness of soft parts, is not amenable to direct pressure. If, for any reason, fixation is decided upon, suspension or extension during correction is indispensable.

As a rule, exercises to increase the mobility of the spine, active and passive correction, and the use of suitable stays or supports, will be effectual.

Exercises I., II., IV. *b*, and V. (pp. 545-547), limited to half a circle; and X. (p. 551) taking care that lateral flexion is towards the convex side, with the spine at the same time hyper-extended, are all useful.

Suspension (XIV. p. 555) may be prescribed, while symmetrical

[1] This does not apply to the use of the reclining couch with head traction which is just sufficient to neutralise the weight of the head and relieve the spine.

[2] Cf. figs. 885-887, Joachimstal, *op. cit.* 5. Lief. p. 1080.

arm-exercises are carried out. The latter are useful means of mobilising and strengthening the spine.

According to Lovett's researches, hyper-extension locks the dorsal region against side flexion, the lateral bending being almost entirely limited to the lumbar region. Side flexion, then, in the hyper-extended position is very important. A good way of attaining the same end is as follows:—The patient lies prone with a pillow adjusted under the sternum, so as to overextend the spine, flexes the knee, and abducts the thigh on the convex side, and with the hand of the same side grasps the leg above the ankle. She now endeavours to get the heel in contact with the shoulder.

Schulthess finds in these cases the accurate localising power of his body-bending apparatus of great effect. He says that in severe cases months may elapse with apparently no result, then quite suddenly mobilisation and improvement follow.

Of lumbar scoliosis in static cases we have already spoken (pp. 475-477).

Lateral flexion with hyper-extension is of use in neutralising the lumbar element in a case of multiple curves, as may be inferred from the above remarks.

Lumbo-dorsal

The ordinary constitutional type is amenable to treatment by exercises—active, passive, and those advised for lumbar scoliosis (p. 536) are suitable, especially No. X. (p. 552). For passive correction, the "redressing" girdle given under total scoliosis may be used.

The severe rickety cases with some kyphosis call for forcible correction, and fixation for a short time followed by exercises performed under suspension.

On no account must the weakened spine be taxed by heavy exercises or by weight-lifting (as advocated by Teschner). A light, well-fitting support and an occipital head-piece should be worn.

Dorsal

Speaking of simple dorsal curves of "constitutional" origin Schulthess says: "These . . . mostly anæmic, slim maidens with weakly built bones, need in the most thorough manner a strengthening treatment. We have, in the first place, to take care to strengthen the skeleton as rapidly as possible, the treatment of the

deformity being thereby delayed. School must under all circumstances be given up, and intervals of rest enjoined in the day. Daily back massage is to be ordered. We must not tax the skeleton and muscles, and exercises are to be performed so far as possible under extension, so that the spine will not be any further pressed together. To aid the cure, the plaster bed in the redressed position may be used.

"These constitutions are not suitable for forcible redressment. If it be attempted, the children after the removal of the corset fall shockingly together, and in the subsequent period a rapidly advancing deformity of the thorax due to increase of the curve is to be expected. Many such girls are not rarely brought to us, because they have become progressively worse in corsets, and our treatment must be limited to the fixation of the existing condition. . . . We must be satisfied with very moderate improvement of the deformity."

With this admirable *exposé* we entirely agree, and it gives a very clear idea of what we mean by "constitutional" and by "skeletal insufficiency." It further shows how unwise it is to place reliance on any one system of treatment, and the great need for careful discrimination.

In the slight simple dorsal cases, in which no bony weakness is anticipated, or those in which this is presumably recovered from, exercises on the lines of those laid down in "total" and "dorso-lumbar" cases may be selected. Further, those based on the self-correction of Lorenz (VI., p. 548) should be tried, and in kypho-scoliosis the manœuvre of Mikulicz (VII., p. 548).

In severe old-standing cases the question of forcible correction may be considered, but not unless patient and surgeon are prepared for prolonged after-treatment. Failing this, the best plan is to over-develop the patient's muscles, especially by horizontal bar and ring exercises. In this class of case Teschner has apparently attained good results, but even here we prefer "suspension" to "loading" and overloading. If rapid correction is attempted, it should be by Wullstein's or by the author's method.

The Compensated Dorsal

So far, the problems of treatment dealt with have been relatively easy; we have had simply to confine our attention to the straightening out of a single curve. But it almost goes without saying that

in the double or S-curve treatment calculated to improve the one may tend to intensify the other. The object to be aimed at is correction; and this is unattainable without preliminary mobilisation. We have already referred to the disputed question as to which is the primary curve (p. 410), but undoubtedly the most difficult to render mobile—at all events by mere exercises—is the dorsal. If we employ mechanical or rapid correction, the dorsal region has some advantage owing to the leverage afforded by the ribs.

We must admit that many points in the treatment of this type—and this is the "classical" type, too—unfortunately yet remain to be formulated, and it is not easy to write dogmatically thereon. For instance, it would be ideal if one could place the patient so as to throw or tend to throw the lumbar curve into passive over-correction, and in this position cause her to carry out exercises for the dorsal curve. This might be possible if some arrangement, such as Volkmann's oblique seat (Fig. 364), could be depended upon to reverse the lumbar curve. However, Lange reverses the left convex lumbar curve by seating the patient as in Fig. 367. The left arm is now free for weight and pulley exercises calculated to reverse actively the dorsal curve.

But, unfortunately, static scoliosis, intentionally produced, is not so simple and regular as the diagram assumes, and Volkmann's oblique seat does not always effect what is desired.[1]

Guided by the same considerations, Hoffa modified the self-corrected position of Lorenz. The pelvis is made oblique by advancing one limb and flexing the knee. The full exercise is as follows:—

(*a*) The patient stands in the Lorenz position (Exercise VII., p. 548).

(*b*) Advances the right limb. She then—

(*c*) Flexes sharply the right knee, and presses hard with the right hand on the ribs. The left elbow is raised as high as possible. Finally, she (*a*) reverts to position (*b*).

These exercises should be tried, but they must be carefully watched to see that they are doing what is intended. The flexion of the knee lowers the pelvis on that side, and is intended to reverse thereby the lumbar curve.

Exercises of lateral flexion in hyper-extension are suggested by Lovett. He claims that in hyper-extension lateral flexion (in the normal spine) takes place almost exclusively in the lumbar

[1] Joach. *Handb. f. orth. Chir.* 5. Lief. pp. 975, 1084, 1085.

region. It follows that lateral flexion exercises should favourably affect the lumbar curve; and at the same time they do not "greatly increase the dorsal curve." They may be performed either on the pelvic stand, or with the patient recumbent, either lying prone or in the lateral position. The words "do not greatly" indicate the necessity for very careful watching and measurements in using this method.

As a mobilising and untwisting or contra-rotating exercise, No. IV. calls for careful trial and study. It is explained on p. 546, and the rationale on p. 547. In the typical right dorsal, left lumbar curvatures the patient bends forward and rotates the shoulders clockwise, so as to untwist the dorsal segment; then hyper-extends and rotates the opposite way so as to influence the lumbar section.

Another method of attempting "active" detorsion we have described and illustrated in Exercise XIII., p. 552. The weight—a moderate one that can be raised—rests on the **sunken** ribs. If the weight is very great this exercise will increase the deformity unless it (the weight) is transferred to the convex side. Lovett's researches[1] show that in a normal spine in the forward bent position (as in Fig. 414, Exercise XIII.) rotation in the lumbar spine is limited. Presuming that this holds good of the scoliotic spine, the favourable effect on the dorsal rotation will not be accompanied by an unfavourable one on the lumbar torsion.

Very considerable "passive" correction may be made by means of simple appliances such as that illustrated in Fig. 382 (Lange). The patient lies, as well corrected as possible, in this for an hour at a time. The thoracic belt thus arranged, however, is not quite free from reproach as far as rotation is concerned.

It is clear, then, that in the S-curve corrective exercises are somewhat problematical. Indeed, so much is this the case that some surgeons seem inclined, even in cases of moderate severity, to dispense with them and to proceed at once to rapid correction. It must be remembered, however, that the results of this method are (as yet) improvement only and not cure, and that appropriate exercises are all the more essential subsequently in order to maintain the improvement.

In any case exercises such as I., II., III., V., VIII., XII., XIV. are mobilising, strengthening, and thereby corrective; while XIV. is intrinsically corrective. Further, if the special manœuvres that

[1] *Lateral Curvature of the Spine*, p. 32.

we have been discussing fail eventually to give satisfaction, daily intermittent correction in some such detorsion-frame as Hoffa's or Schulthess' cannot fail to do good. In this country, however, so far there has been a desire to avoid elaborate apparatus. It is difficult to see why, as in reality they simplify the problem.

Finally, even in moderate cases, much time is gained by rapid correction, and in severe cases it is often essential. We have elsewhere discussed this matter. The jackets are left on for a month or longer, and renewed until no further correction is obtainable.

When the plaster jacket is discarded, exercises,[1] massage, and recumbency must all be intelligently used. The patient's hope now lies in the development of the muscles. And, finally, a support — either spinal stays or Adams' — is fitted until the muscles have sufficiently recovered. It is unreasonable to take a patient out of plaster and subject the muscles to prolonged work at once. Therefore recumbency and supports have their place in after-treatment as well as exercises.

Cervico-Dorsal Scoliosis

This form is difficult to treat. Any cause, such as torticollis or a cervical rib, must be separately attacked. In an early case, a spinal support, with an occipital head-rest, or a jury-mast after the Sayre pattern, may be of use in the intervals between exercises.

The curve must be mobilised by Exercises V. and VI. (*d*) (p. 547); and by arm exercises carried out under suspension.

We have seen that in cervical cases one of the worst factors is the marked overhanging of the trunk, compensatory to the cervico-dorsal curve. An attempt should be made to neutralise this by an appropriate support, in the hope that the efforts of the patient to bring the head erect will tend to straighten out the cervical curve.

Treatment of the Clinical Types

The actual treatment to be prescribed in the individual case depends on so very many considerations that it becomes a difficult

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matter to lay down specific directions. The cause, stage, duration, prognosis, and so on, have all to be borne in mind. Directions quite appropriate for a total scoliosis depending on "occupation" would be quite inappropriate for total scoliosis arising in the course of rickets. Still, some idea may be conveyed of the most likely methods to be of use, especially if the reader bears in mind that we are speaking of the treatment of **clinical types,** the ætiological factor being constitutional, unless otherwise stated. That is, we are dealing more especially with the clinical types as seen in adolescent girls and lads.

Before doing so, it is essential to give a brief sketch of "gymnastics" and its therapeutical developments, with illustrative examples, to which reference can be made.

GYMNASTICS AND EXERCISES

They may be classified into—

I. **Active.**
- (*a*) *Without resistance.*
- (*b*) *With resistance.*
    - (*a*) The patient performs the movement which the assistant resists.
    - (*β*) The assistant moves the part, while the patient resists.

II. **Passive.**
- (*a*) *Massage.*
- (*b*) *Manipulations.*

I. (*a*) **Gymnastics and Exercises without Resistance.**—The patient, unassisted, at the word of command of the instructor, performs certain movements; for example, extension of the arms above the head, or touching the toes with the tips of the fingers.

Exercises without resistance may be—

(*a*) Of a general developmental character.

(*β*) Selected and adapted to meet definite therapeutical requirements; for example, the treatment of scoliosis.

(*a*) *General Developmental Exercises.*—This is not the place to deal *in extenso* with exercises of this character. For detailed information any of the ordinary manuals on gymnastics may be consulted. But since "setting up" drill can be made to play such an important part in the prophylaxis of scoliosis, the subject must be shortly referred to.

The most casual observer cannot fail to notice the marked difference in appearance, gait, and bearing between the smart soldier and the slouching, raw recruit, and a little reflection will show wherein this difference lies. As we have already pointed out (p. 401), muscular movement of a co-ordinated character is no simple matter; indeed, standing erect or balancing on one foot, if one comes to analyse it, is remarkably complex. And the principal factor in this instinctive co-ordination is the education of what is known as the "muscular sense." Simple gymnastics start with the assumption of a first or fundamental position. The pupil stands erect, heels together, toes out (although it is doubtful if this is wise; see Flat Foot, p. 682), knees and hip-joints extended, spine symmetrical, and eyes to the front. At first sight it may seem a waste of time to teach anything so elementary, that is to say, to tell a patient to stand up straight. Yet experience proves that many persons are quite unable to adopt correctly this simple attitude, apart from any existing deformity, and have to be drilled and educated accordingly.

How definitely the control of muscle action has to be learnt is well shown by observations on the after-history of transplanted muscle (vol. ii. sect. xi.). More or less wide movements are represented in the cortex cerebri, but the re-presentation of individual muscles has to be acquired. Also the development of the individual muscles, by concentrating nervous energy on the production of a maximal contraction, is the chief cause of the success of some of the somewhat monotonous methods of physical culture. For example, it seems somewhat absurd for a pupil to walk, say, a mile to his lesson in Swedish gymnastics, and during the lesson, amidst other exercises, contract his ilio-psoas, say, a dozen times, since on his way to the teacher he has already done so a thousand or so. The difference is, however, that in one case the action is almost unconscious or automatic, in the other it should be performed with concentrated mental effort. Another point is that, as the muscles come under control, a distinct improvement in cerebration is noted; or, in other words, the development of the nervo-muscular elements favours the development of the mental condition, being an example of the interaction of body and mind.

Sufficient has been said to indicate that simple gymnastic exercises should form part of every educational curriculum. Not only will the development of many orthopædic conditions be more

or less hindered, but the onset of any departure from normal form is promptly detected.

A word of caution is needed as to duration of exercises. They must not be pushed to the stage of fatigue, or be hurried, irregular, or jerky. Further, since, generally speaking, inspiratory movements, such as erection of the trunk, and expiratory movements, such as forward bending, are made to synchronise with inspiration and expiration respectively, the exercises must be done slowly so as to avoid rapid respiration.

Many simple developmental exercises are utilised in the treatment of scoliosis, and, when so used, become a part of medical gymnastics. They will be described below. But a description of the system as a whole must be sought for elsewhere.

(β) *Selected Exercises of Use in Scoliosis.*—These are useful for the cure of slight postural cases, and are helpful in types. They have the advantage of requiring a minimum of apparatus, and are therefore well suited for home treatment. Some are performed in the erect position, the spine being subjected to the superincumbent body-weight and the longitudinal muscle tension. Others are performed in the horizontal position over the end of a table or couch, and here the effect of the body-weight is reduced to a minimum (Lovett), but the longitudinal muscle tension is increased (Vincent Moxey). In either position the exercises may be symmetrical or asymmetrical.

Lovett has systematised them, and exhaustively analysed their effects. While departing somewhat from his classification the author is much indebted to his descriptions.

A word of warning is necessary. The exercises may be simple, but the scolioses which come up for treatment rarely are so, and exercises which act favourably on one curve may readily intensify compensatory curves. This is the chief reason for the limitation of these means of treatment, and it has led to the invention of the somewhat complex mechanical appliances so generally in use on the Continent. When we said "home use" it was not intended that skilful and intelligent supervision could be dispensed with.

Many of these exercises are useless unless the pelvis is fixed, as so much of the apparent spinal movement is really due to the mobility at the hip-joints causing pelvic obliquity. Some surgeons fix the pelvis by a stout belt fastened to a post; others use pads, working from a post either side. Lovett prefers the pelvic clamp

of Bade.[1] This is an upright post fixed in a round platform of sufficient size to stand firmly. The upright post carries an adjustable wooden clamp.

EXERCISE I. *Voluntary Redressment of the Spine.*—It is obvious that, *cæteris paribus*, the longer the spine is, the straighter the patient is; in other words, in order to make herself taller, the more she must straighten her back. Golding-Bird,[2] Kjölstadt, Kirmisson, Tidemann, and others, have attached great importance to this exercise, and modified it in various ways. Golding-Bird's method roughly is to ask the patient to stand against a wall or door, and stretch to her utmost height. Kirmisson uses a special double post against which she stands, the pelvis is secured by a belt, and in the attitude of redression arm movements are practised.

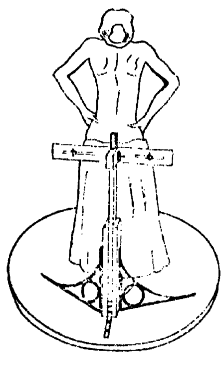

FIG. 399.—Spinal Exercise I. Voluntary Redressment of the Spine (R. W. Lovett).

The best way to perform it is as follows (Fig. 399):—The patient stands in the "fundamental" position, that is, heels together, knees and hips extended, spine straight, head erect, eyes front, shoulders back, arms hanging at the sides, and the palms touching the hips. She now stretches upwards, making herself as tall as possible. Children may be encouraged to touch the surgeon's hand held just above the head. The shoulders are not to be raised (shrugged), nor the heels to leave the ground. As the patient straightens herself she **inspires**, holds herself a few seconds in the redressed position, then relaxes somewhat to the fundamental position, and **breathes out** whilst doing so—the exercise being repeated a dozen to twenty times. This exercise may be modified in various ways.

Tidemann fastens a belt round the patient's hips, with side-attachments which the patient grasps. As she straightens herself actively, she as it were pushes the pelvis downwards with the arms, so that the spine is both actively and passively stretched. The pelvis is not fixed.

The author sometimes has this exercise performed before a cheval glass, the anterior median line of the trunk[3] being marked out. The pelvis must be fixed, or at all events steadied.

Vermeulen directs it to be performed under a movable horizontal bar, so that the actual limit of extension reached can be measured.

This is a very useful exercise, applicable to nearly all cases of

[1] Lovett, *op. cit.* Fig. 84, and *Zeitschr. f. orth. Chir.* xii. 4, p. 799.
[2] *Guy's Hosp. Reports*, 1888, p. 91.
[3] If a plumb line be suspended between the patient and the mirror, it enables her to judge when a median line marked on her body is truly vertical.

scoliosis, but especially to the functional forms. There is no danger whilst straightening the primary of adversely affecting any compensatory curve. Some of the gain in height is, of course, due to the straightening of the physiological curves. On the scoliosis it is corrective and mobilising. The erectores spinæ and all spinal extensors are strengthened, and the respiratory capacity increased.

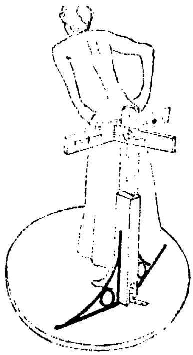

FIG. 400.—Spinal Exercise II. Strengthening the Extensors of the Spine and Erectors of the Trunk (R. W. Lovett).

EXERCISE II. *To Strengthen the Extensors of the Spine and Erectors of the Trunk* (glutei).—The patient, with the pelvis steadied, *e.g.* against a table, and with the hands on the hips, bends the body forward, the spine being held rigid, and the movement taking place from the hip-joints. As she does so she breathes out. She then slowly brings the trunk back to the erect position, and in doing so inspires (Fig. 400).

If the pelvis is more or less fixed, so that balance has not to be considered, as in Bade's stand, this exercise really approximates to the one to be described presently of extension in the prone position.

If the patient clasps her hands behind the neck, instead of keeping them on the hips, the work performed is increased.

EXERCISE III. *Swimming.*—The patient, fixed in the pelvic stand, bends forward, but keeps her eyes, not on the floor of the room, but towards the wall, that is to say, the neck is extended. The elbows are flexed and the hands rest on the chest. The arms are then extended in front of the head, as in swimming, and brought round to the sides of the body, and regain the original position (Fig. 401).

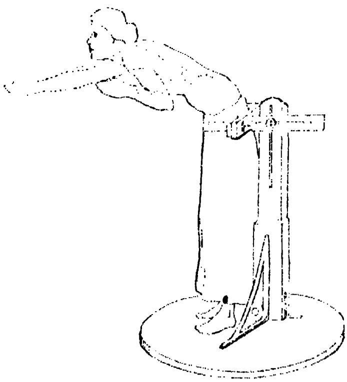

FIG. 401.—Spinal Exercise III. Swimming Movements (R. W. Lovett).

This exercise puts more strain on the extensors and glutei, and in addition strengthens the muscles of the shoulder girdle. It is valuable in round shoulders.

EXERCISE IV. *Trunk Twisting.*—This excellent exercise is essentially the outcome of Lovett's own researches, and needs careful study.

The patient stands, if we desire to increase the general mobility

of the spine, with the feet firmly planted, heels touching, and the hands behind the neck. No pelvic support is used. She then twists alternately to the left and right, looking right round over her shoulders (Fig. 402).

As a corrective exercise it is performed :—

(*a*) In slight general curves in the erect posture, with the pelvis fixed.

(*b*) If the exercise is required for a curve in the lumbar region, the twisting of the trunk must be performed in the hyper-extended position.

(*c*) If in the dorsal region, the flexed position is adopted.

The explanation for this variation in the position of the spine will be found on p. 540.

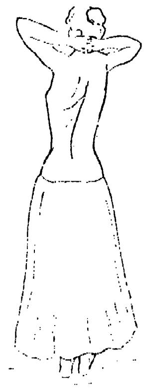

FIG. 402.—Spinal Exercise IV. Trunk Twisting (R. W. Lovett).

EXERCISE V. *Trunk Circling.*—The patient is erect, and the pelvis is fixed. The body is then bent forward so as to flex the spine; from this position it is brought into the left lateral, and then is hyper-extended. In order to complete the circle the body is now flexed forward, then into the right lateral position, and is finally brought erect. By this exercise the trunk is as it were circumducted (Fig. 403). When employed in this way the exercise serves to render the spine more mobile. If we are dealing with a principal curve, *e.g.* a lumbar curve to the left, and if the lateral bending be limited to that side which improves the curve, then the exercise becomes corrective.

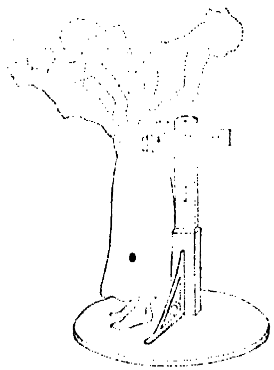

FIG. 403.—Spinal Exercise V. Trunk Circling (R. W. Lovett).

A similar procedure for high curves, but limited to the cervical region, serves to mobilise them. If restricted to the side which improves the curve, it becomes corrective.

So far the exercises described have been "without resistance," chiefly symmetrical, and almost entirely active, but it is not possible to maintain rigidly for some of the following exercises the classification above given, as analysis of the next will show :—

EXERCISE VI. *Self-Correction, after Lorenz.*—(*a*) Suppose the case is one of right dorsal convexity. The patient is in the erect position with the pelvis fixed. She then places the right hand behind on the prominence of the ribs, which she grasps between her thumb and index finger. The left arm is thrown up over her head, the tips of the fingers touching the right ear. She presses the rib-

prominence with the right hand and simultaneously straightens her back out as much as possible (Fig. 404).

Analysis.—The effect of the position of the right upper extremity is to stretch *passively* the dorsal curve, while the hand pushes in the prominence of the right ribs, just as the pressure-plate of a mechanical appliance does. At the same time the spine is *actively* redressed by the elevation of the left shoulder and its effect on the concave side of the curve. This is then an asymmetrical exercise in which both active and passive forces are combined.

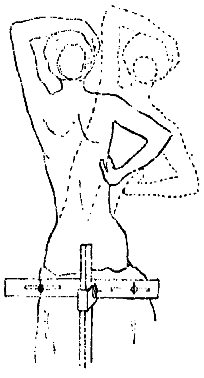

FIG. 404.—Spinal Exercise VI. Self-Correction, after Lorenz (R. W. Lovett).

The fallacies are that the pressure exerted by the right hand in this position is very slight; that if care is not taken it may increase the rotation rather than diminish it; that pressure may not affect the dorsal, but simply increase the lumbar compensatory curve. Self-correction is, however, useful in dorsal scoliosis provided that trial shows it is effecting its object. It may be modified by raising and depressing the left arm synchronously with respiration.

(*b*) *Hoffa* combines the Lorenz exercise with tilting of the pelvis. The right leg is advanced with the object of passively correcting the lumbar curve (Fig. 405). But the conditions then become rather too complex for satisfactory analysis. Of course in Hoffa's method the pelvis is not fixed.

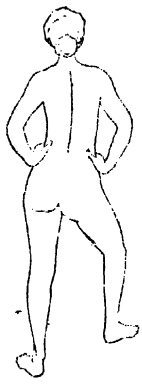

FIG. 405.—Hoffa's Modification of Lorenz' Self-Correction (R. W. Lovett).

(*c*) *Mikulicz* thus modifies this active-passive correction. In the case of a right dorsal, left lumbar curvature the patient presses the right hand on the rib-prominence, and the left presses in the left loin. She then bends to the right, whilst pressing in with the right hand, then to the left whilst pressing with the left.

(*d*) *In cervical cases, e.g.* a right cervico-dorsal, the patient may passively correct the spine, by placing the left hand on the left side of head, the right on the right thoracic wall, and pushing the head as far as possible over to the right side, whilst the right hand exerts counter-pressure.

EXERCISE VII.—An exercise of Mikulicz, which Lovett speaks of as especially useful in dorsal kypho-scoliosis, is as follows:—

The patient stands with the pelvis not fixed, the hands are loosely clasped behind the back, the elbows are extended, with the hands resting on the sacral region. She bends forward, flexing the spine, and then straightens herself up vigorously, pulling her shoulders back, and approximating her scapulæ as much

as possible. Then she "describes a half circle to the right or left to the hyper-extended median position."

We now come to exercises in the *recumbent* position. Strictly speaking, since they cannot be performed unassisted, they do not come under the definition of simple. The patient's legs must be steadied by the assistant, or by a strap round the table. There is, however, resistance to the actual spinal movement. Exercises in the prone position require very careful consideration. It is held by some that they are less severe than those in the standing position, and it is true that in the intervals between the active contractions the patient is completely at rest. But they are more arduous than those already given, and for the following reasons. The weight of the trunk has to be lifted, and that in a disadvantageous position, consequently the tension of the longitudinal spinal muscles has to be much increased. Instead of the slight co-ordinate contraction required in balancing, strong contraction is needed to resist the dead-weight of the parts. This is shown by the increased rapidity of the respirations. Lovett[1] states that the spine, when prone, is less curved than in the upright position, and is slacker and more easily capable of side displacement. This is true, provided we are dealing with the **relaxed** spine, and holds good for manipulations and **passive** exercises. In the present connection, however, it is probably a fallacy. There is something in the contention that more specialised exercises can be given in the recumbent position because there is no question of balance. An advantage of exercises in the prone position is the aid to an accurate appreciation of the varying phases of the patient's condition by the plane of the table.

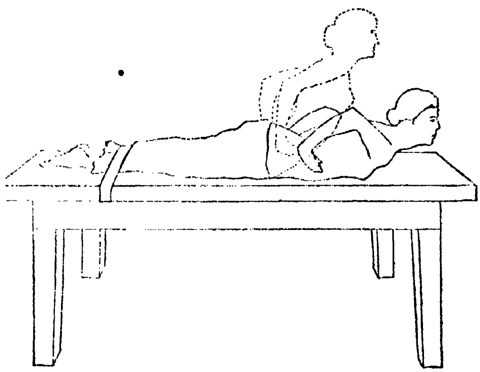

FIG. 406.—Spinal Exercise VIII.*a* (R. W. Lovett).

EXERCISE VIII.—The patient lies prone on a table, the legs being secured by a strap across the ankles, whilst

(*a*) The hands rest on the hips, the elbows are held well back, and the scapulæ are approximated.

[1] *Op. sup. cit.* p. 130.

The patient then hyper-extends the spine, and inspires whilst doing so, and breathes out in relapsing to the original position (Fig. 406). Or

(*b*) The hands may be placed as in the Lorenz self-correction position (Fig. 404).

(*c*) Or they are clasped behind the nape of the neck. Or

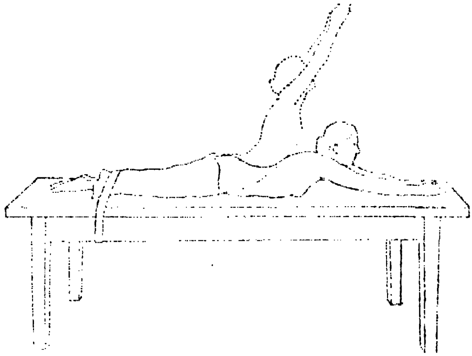

FIG. 407.—Spinal Exercise VIII.*d* (R. W. Lovett).

(*d*) They are extended in front of the head (Fig. 407).

The muscles strengthened are the extensors of the spine and the glutei. Hyper-extension takes place chiefly below the tenth dorsal vertebra.

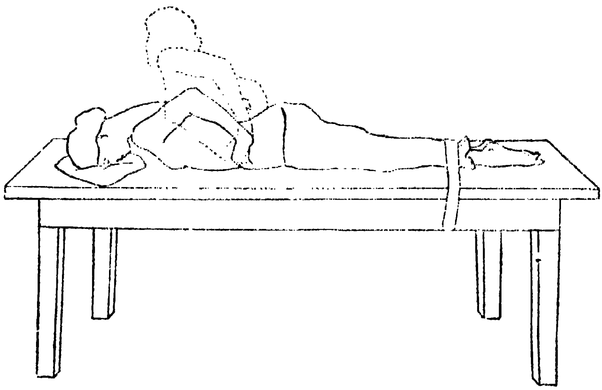

FIG. 408.—Spinal Exercise VIII.*e* (R. W. Lovett).

This exercise must not be used if there is any great degree of lumbar scoliosis. The work to be done is graduated by the position of the arms. The farther forward they are held the greater the exertion.

(*e*) A modification in which the arms are held folded behind the back, as high as possible in the dorsal region, is very useful in dorsal kyphosis or round shoulders (Fig. 408).

(*f*) The work done by the erectors of the spine and glutei may be further increased by making the patient flex the trunk over the end of the table (Fig. 409) with the head pointing to the floor. From this position she gradually raises herself to the fullest hyper-extension, the muscles involved being put through a large range of movement. This is a severe exercise.

EXERCISE IX. A sign of general muscular weakness is an increase of the lumbar lordosis. To remedy it, exercises for strengthening the abdominal muscles are useful.

The patient lies flat on the back, with the arms folded, the legs being secured by a strap, and slowly raises herself to the sitting-up

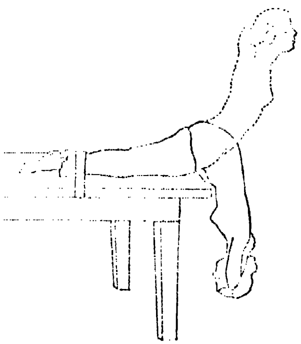

FIG. 409. Spinal Exercise VIII, *f* (R. W. Lovett).

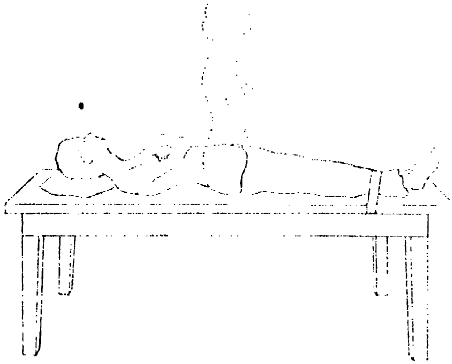

FIG. 410.—Spinal Exercise IX, to strengthen the Abdominal Muscles (R. W. Lovett).

position (Fig. 410). Then steadily, with the spine rigid, she sinks to the original position.

EXERCISE X. When the requirements of the case call for it—that is, if a trial shows the effect to be satisfactory—exercises can be carried out in lateral recumbency. In these the extensor muscles of one-half of the spine only are engaged (Fig. 411).

EXERCISE XI. *Trunk circling* (Fig. 412) in the prone position over the end of a table is a severe muscular and mobilising exercise. If needful, the lateral flexion can be limited to one side only.

RESISTED EXERCISES

It is hardly worth while, especially in the case of spinal ercises, to labour the difference between the α and β type e p. 542). Taking flexion of the forearm as an example, if the tient flexes against the resistance of the gymnast the biceps is engthened; if the patient resists an attempt to flex the forearm

made by the gymnast the triceps is strengthened. An example of the original Swedish system is as follows:—

EXERCISE XII. The patient leans against a bar, and, bending forward, grasps a rod held by the assistant. The patient now straightens himself up against the resistance offered by the gymnast.

The advantage of this method is the careful and intelligent supervision of the task by the assistant. The disadvantage is that each patient requires the sole attention of one person. To obviate this Zander, Fischer, Beely, and others have invented the well-known medico-mechanical gymnastic apparatus. Schulthess of Zurich has especially turned his attention to this aspect of the

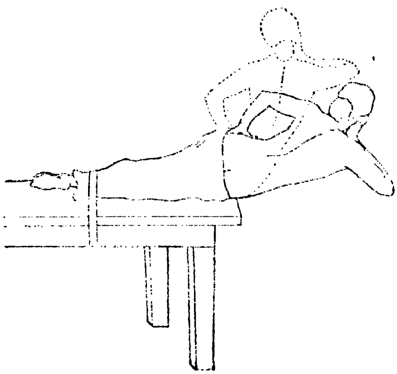

FIG. 411.—Spinal Exercise X. Lateral Extension (R. W. Lovett).

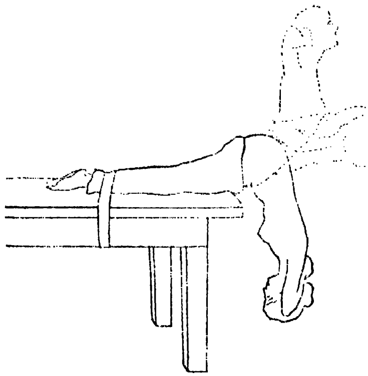

FIG. 412.—Spinal Exercise XI. Trunk Circling (R. W. Lovett).

treatment of scoliosis, and with excellent results. Good representations of the apparatus are given in Joachimstal's *Handbook of Orthopædic Surgery*, figs. 913 to 916. They provide both active and passive exercise, as, for example, his shoulder-pushing apparatus (Fig. 413). The patient's spine is passive, stretched in suspension, whilst she actively raises the right shoulder. The great point about these appliances is the accuracy with which their action can be localised, and the resistance is naturally more even and regular than in the primitive Swedish method.

EXERCISE XIII. A very simple resistance appliance is the Schulthess' "rib-raising apparatus," a modification of the Fischer-Beely machine. The pressure-pad is adjusted, not to the convex, but to the *sunken-in* ribs, which the patient actively raises.[1] We wish to lay special stress

[1] Joachimstal's *Handb. f. orth. Chir.* p. 1135.

on this point. It is customary to make the patient straighten her spine against the pressure of the surgeon's hands on the rib and loin prominences. That is to say, the muscles are stimulated, by resistance, actually to make the deformity worse.

FIG. 413.—An apparatus designed by Schulthess for actively raising the right shoulder.

In speaking of "resisted" exercises, we may mention Teschner's method of raising heavy dumb-bells and bars, weighing up to 30 lbs. or more, a method to be entirely condemned. It is true that carrying loads on the head induces an erect carriage and a straight spine in normal persons, but the scoliotic has already, unfortunately, demonstrated

that his spine is in no condition for weight-bearing. Teschner's views have only to be exaggerated slightly, and scoliosis would no longer exist. That is to say, the weight must be increased until the spine *does*

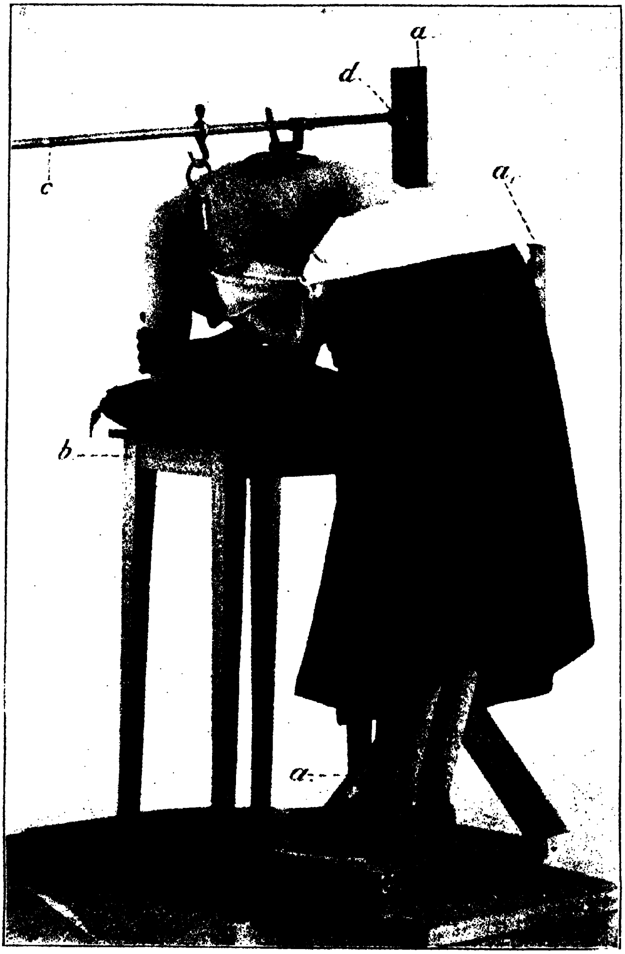

FIG. 414.—Spinal Exercise XIII. Schulthess' Apparatus for actively raising the Sunken Ribs.

straighten itself, which is absurd. We do not deny that in some, and especially severe cases of old standing, the best that can be done for them is to stimulate supernormal muscular development.[1]

[1] Klapp has recently advocated creeping exercises as a means of mobilising the parts. It is very likely of some use in kyphosis, since in progression on all fours the

PASSIVE EXERCISES

(a) Of *massage* in general (p. 500), and of its employment in scoliosis, we have already spoken on p. 501.

(b) *Manipulations.*—Manipulations designed to correct the deformity are probably of even more importance than "active" exercises. Schulthess,[1] in an article dealing with Klapp's creeping method, says: "The strengthening of the musculature and athletics for the back does not protect from scoliosis. Normal posture requires not only good muscles, but also good bones. There are subjects of severe scoliosis who are good gymnasts. Excessive muscular development brings the scoliosis out more markedly! (prägt die Skoliose schärfer aus)." This is to every orthopaedic surgeon a matter of common knowledge, and experience has abundantly proved that reliance cannot be placed on active exercises alone. We have already referred to this, and we here emphasise that improvement is to be expected by methods designed to straighten the spine, rather than trying to get the patient's muscles to "pull" it straight.

Wullstein's[2] demonstration of the effect of forcible extension on the corpse of a scoliotic woman is very convincing, but of course no such result is attainable by the mere body-weight of the patient, Pressure effects can be combined with extension by means of "detorsion" apparatus. Or "detorsion" appliances can be used in recumbency with the spine slack, as in Lovett's method.

A few examples of passive correction will be given.

EXERCISE XIV. *Suspension by the Head in a Sayre's Sling.*—This is a useful mobilising and corrective procedure, suitable to almost any

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physiological curves are straightened out. But it leads to too much development of the shoulder muscles, and a high, ungainly position of the shoulders. Probably all that can be gained by "asymmetrical" sideways creeping, can be more accurately done by other methods. At all events, the plan is simple and easily tried.—"Über die Behandlung der Skoliose mit dem Kriechverfahren," *Zeitschr. f. orth. Chir.* xvi. p. 28. The exercises are carried out by the patient crawling on hands and feet like some quadrupeds, such as the camel, the hand and foot of one side being approximated, while those of the other side are separated. As an example let us instance those for right dorsal curvature:—"1. The child crawls in a straight line, till he has acquired the 'quadruped' gait. 2. With each step forward the head is inclined towards the side on which the hand and knee are approximated. 3. At each step the hand and knee which are wide apart are brought over and cross the limbs on the other side. 4. To open out the concave left side, he crawls in a circle towards the right." (Thomson and Miles.)

[1] *Zeitschr. f. orth. Chir.* xvi. p. 146. [2] Joachimstal's *Handb.* figs. 858, 859.

case. Rotation as well as lateral deviation is diminished. To obtain a maximum effect the patient's thighs can be strapped down to a seat.[1]

A less forcible, but somewhat more localising effect is obtained by using a suspension trapeze of two parallel bars, the distance between

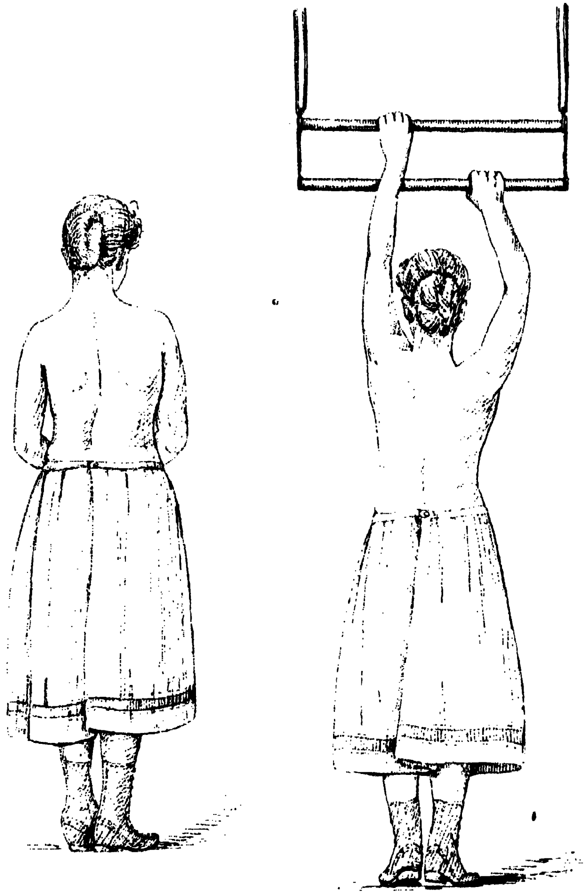


FIG. 415. FIG. 415a.

Spinal Exercise XIV. Straightening the Spine by using Trapeze-bars.

which can be adjusted. The hand of the convex side grasps the lower bar, and of the concave side the upper bar (Figs. 415, 415a).

EXERCISE XV. A good combined active-passive stretching exercise is thus described by Lovett under the title, "Partial Suspension by one

[1] During suspension, arm exercises with light dumb-bells can be advantageously used.

Arm with the other Arm and Leg Locked." The patient standing under a bar that can be reached without rising on the toes, grasps the bar with the hand of the side on which the spine is concave. On the opposite side—the convex—the arm passes under the knee, the thigh being flexed at the hip. The shoulder and pelvis are thus approximated :—

1. The patient thus standing on one leg flexes the knee, and allows the body-weight to come upon the arm.
2. The original position is resumed. This exercise is suited for total and dorsal curves.

FIG. 416.—A Case of Right Dorsal and Left Lumbar Scoliosis. The patient is placed in Lovett's Horizontal Correction Frame.

FIG. 417.—The same patient as in Fig. 416, with Side Pressure applied to the Dorsal Curve by a strap (R. W. Lovett).

EXERCISE XVI.—A simple method of obtaining passive correction by suspension with lateral traction[1] is illustrated in Figs. 416, 417; but there is great risk[2] that in correcting the lateral curves by direct lateral pressure, rotation may be increased.

To obviate this, in the detorsion machines of Hoffa and Schulthess pressure pads are applied perpendicularly to the surface of the rib-prominence, also a pad on the prominent ribs above.[3] Space does not permit us to give figures of all these appliances; the principle, however,

[1] Intermittent correction in the vertical and suspended position.

[2] As pointed out by Schulthess and others. See also on this point Lovett's *Lateral Curvature*, pp. 151, 152.

[3] Berger et Banzet, *Chir. orth.* figs. 64, 65, pp. 68, 69.

is just the same as by Wullstein's apparatus or by the author's method for correcting the patient during the application of a plaster corset (see pp. 523-528). Schulthess places the patient in the apparatus for ten to twenty minutes daily, and has an arrangement added by which the arms can be exercised by a weight and pulley mechanism.

EXERCISE XVII. *Intermittent Correction in the Prone Position with the Spine Slack.*—On mechanical grounds, and as the outcome of certain experiments on the cadaver,[1] Lovett concludes:—

"That an upward pull on the head is a corrective force in the normal spine, but that much more force is required to accomplish a certain amount of side correction than is the case if the force is applied laterally." Also, "that the maximum of side displacement is obtained by side-pressure in the slack spine, that is, in a spine not stretched in its length."

The natural deduction is that intermittent correction is best carried out with the patient prone, and free from any head traction appliance. To carry this out in practice, an apparatus has been invented by D. Z. B. Adams of Boston.[2] Lateral deviation and rotation can be separately corrected, and the flexed position of the patient's thighs over the end of the table by diminishing the lumbar lordosis renders the spine still more controllable. The correction is made daily for fifteen to thirty minutes, or so long as the patient can bear it.

The respective merits of the procedures XVI. and XVII. have yet to be decided. If we accept Lovett's conclusions, the risk remains that without great care correction in the slack spine is likely to increase the compensatory curves. The pressure on the rib-prominence is simple enough, but to obtain counter-pressure in the lumbar region is not so simple. Under moderate suspension, increase of the secondary curvature is less likely to happen. In practice the Continental or upright method is easier to carry out, as we are able to judge of the shape of the patient much more readily in the vertical than in the longitudinal position. Some patients bear suspension badly, and on them the method (Exercise XVII.) should be tried. It must be borne in mind that in vertical suspension the spine is really "slack," so long as the pull is only about equal to the weight of the upper parts of the body. Up to a certain point suspension means merely an unloaded spine, and accordingly a "slack" spine, since longitudinal tension of muscles and weight are co-existing forces. But beyond this point a suspended spine becomes a "stretched" and "tense" structure.

In "total" cases the exercise No. XVII. is unsuitable; the necessary counter-pressure above tends to cause an *ſ*-curve in the cervico-dorsal region, and it is inapplicable to cervical cases.

[1] *Op. sup. cit.* p. 145. [2] *Ibid.* p. 147.

CHAPTER VII

KYPHOSIS, ROUND SHOULDERS, AND FLAT CHEST

Kyphosis of Infancy, Childhood, Adolescence, Adult Life, and Old Age—The Rickety Spine—Neuropathic Kyphosis—Hereditary Hump-back—Round Shoulders and Flat Chest—Occupation Kyphosis.

THE conditions other than destructive lesions, such as tuberculous caries, malignant disease, and syphilis, causing kyphosis may be advantageously considered from the point of view of the age at which the deformity in the spine commences:—

I. **Kyphosis of Infancy** is due in many instances to feeble muscular development and rickets. It must be borne in mind that at birth the lumbo-sacral lordosis is very feebly developed, and the whole spine readily falls into the early kyphotic condition. As the development of the spinal extensor muscles advances *pari passu* with the age of the child, the normal lordoses, characteristic of the erect attitude, appear. The shape of the spine in the seated infant is a total kyphosis, and many total or partial[1] kyphoses of later infancy must be regarded as the stereotyping of an earlier condition. That is to say, for some reason the changes in the spine, associated with functional development, have been retarded.

II. **Kyphosis of Childhood.**—Causes:—

(*a*) After rickets.

(*β*) The result of infantile paralysis.

(*γ*) Associated with the late stage of pseudo-hypertrophic muscular paralysis.

[1] This is a convenient place to refer to what we mean by total and partial kyphosis. The normally distributed dorsal kyphosis may be exaggerated, yet not encroach on the lumbar lordosis. Indeed, the lumbar lordosis may more than hold its own to compensate the reverse change in the dorsal region. The dorsal kyphosis may encroach on the lumbar lordosis partially, or in some rare cases totally. In the totally kyphotic spine, in order to restore the balance, compensation is induced by diminished inclination of the pelvis, and flexion at the knees and ankles, a condition well seen in some senile kyphoses.

(δ) Associated with chest deformities, such as occur with adenoids of the naso-pharynx.
(ε) Hereditary hump-back.

III. **Kyphosis of Adolescence.**—Round shoulders and faulty attitude.

IV. **Kyphosis of Adult Life**, due to—
(α) Occupation, *e.g.* cobblers, tailors, porters.
(β) Muscular and gonorrhœal rheumatism.
(γ) Arthritis deformans.
(δ) Osteitis deformans.
(ε) Osteomalacia, or mollities ossium.
(ζ) Progressive muscular atrophy.
(η) Bronchitis and emphysema.

V. **Kyphosis of Old Age.**—All these kyphoses are distributed over considerable regions of the spine, and are not short and acute or angular as in destructive lesions. Still, occasionally the kyphosis of Pott's disease is rounded and presents diagnostic difficulties. Schulthess points out that in caries, if the transverse contour of the trunk be noted, the spinous processes form the most prominent projection backwards, whilst in the kyphoses with which we are now dealing the rib angles are more or less prominent.

The Rickety Spine

Many infants as a result of rickets or of general debility are unable to sit erect at the proper age. When they attempt to do so they are found to be nearly powerless, or are so weak that the body inclines forwards, or the back is so much curved that the head drops forward until it may even reach the knees.

The important point in these cases is the diagnosis. Whilst the rickety spine is most commonly met with during the second year of life, tuberculous spondylitis is not unknown at that age, and many mistakes have been made. Although the rickety spine is usually equally curved, such a condition is not uniform. In severe rickets the curve is seen to be interrupted by an angle near the dorso-lumbar region, and the general tenderness of the parts gives a close similarity to Pott's disease. But the laxity of the muscles, the presence of other signs of rickets, and the absolute freedom of movement in all directions, are valuable diagnostic signs. Further,

if the child be suspended from the axillæ a rickety curve disappears. If Pott's disease be suspected—and it is very easily overlooked at this age—the sign most relied on by the writer is the absence of hyper-extension of the spine (see vol. ii. sect. v.). This, taken with the persistence of the curve on suspension, is diagnostic of Pott's disease.

The actual form and regional distribution of a rachitic kyphosis vary with the severity and stage of the disease and the age of the patient. Thus, in the acute stage of rickets, that is, in early infancy, the kyphosis is total and the lumbar lordosis is reversed. This is a condition of muscular weakness, not, of course, of bony deformity. As time goes on and the post-rachitic stage is reached, the deformity disappears, or the cases are spontaneously cured in other ways; or else they transform into "round" backs, in which the dorsal kyphosis is somewhat increased and encroaches on the lumbar lordosis, and is compensated at the lumbo-sacral angle and by the position and inclination of the pelvis. That is, the round back sometimes seen in adolescence and due to rickets is seen. Again, the rachitic kyphosis may persist as an increased dorsal kyphosis which is compensated by exaggerated lumbar lordosis, and the "hollow round back" type arises. We shall shortly refer to these types again and explain them. The "hollow round" back is sometimes spoken of as the rachitic attitude; but in the first place, as it is met with in other subjects, and in the second, the bulk of the post-rachitic patients conform to the round back and not the hollow round back type, the expression is misleading.

We have above used the words "not of course of bony deformity." This does not imply that all bony deformity due to rickets is absent. The increase of the dorsal kyphosis itself is a bony deformity. It only means that the bulk of the lumbar kyphosis is not fixed, and is not due to actual alteration in the shape of the vertebræ; but some actual structural diminution of the lumbar lordosis may eventually result, in which the "flat-back" condition ensues. In the flat back both the normal lumbar lordosis and dorsal kyphosis are diminished, at all events the lumbar lordosis is less than normal. Such cases are often stated to be peculiarly liable to scoliosis; about this point there is some doubt.

The treatment of a rickety spine when severe, with the back almost powerless, is recumbency. The late William Adams' plan of directing the child to be nursed as much as possible in the reclining position, or to be carried about in a padded wicker tray

(Fig. 398, p. 532), is very useful.[1] We have proved the efficiency of the wicker tray on many occasions. If the child is able to sit up, but with the spine bent, a back-board of leather, with axillary and perinæal straps attached, is useful (Fig. 418). It gives complete support to the spine and firm fixation. As the spinal curves are not developed till the child begins to walk, it is essential that the back be kept as straight as possible during infancy. The general condition demands attention, and rickets must be appropriately treated.

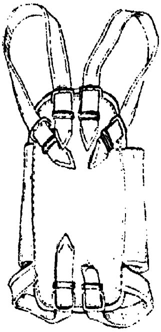


FIG. 418. — Adams' Back-board, used in the Treatment of Rickety Spine. The upper straps are for the shoulders and the lower pass around the perinaeum. Soft webbing is buckled across the front of the Trunk.

NEUROPATHIC KYPHOSIS

In addition to von Bechtereff's disease, to be described, kyphosis is met with as a result of anterior poliomyelitis,[2] pseudo-hypertrophic paralysis, progressive muscular atrophy, sciatica, and locomotor ataxia. And Delgarde[3] describes a hystero-traumatic kyphosis, and recommends application of ethyl-chloride to the spine, or in obstinate cases injection of a one per cent cocaine solution.

Kyphosis is also seen in idiots, cretins, some cases of infantile paralysis, and cerebral diplegia, and in some varieties of osteo-arthropathy. This matter will be dealt with under the heading of "Deformities of the Thorax."

HEREDITARY HUMP-BACK

The late William Adams[4] drew special attention to this form of kyphosis, and quotes a remarkable instance. A man, the father of five children, was "short and dwarfish, with an extreme degree of hump-back. He walked tolerably erect, but his head appeared to sink in between his shoulders, and his chest was much deformed.

[1] *Lect. on Curv. of Spine*, 2nd ed. p. 63.

[2] The kyphosis of paralysis or paresis, like that of rachitis in early infancy, is total. It is not fixed, and the patient in attempting to assume the erect position may do so by throwing the trunk backward until it is supported by the tension of the anterior body wall. So that, paradoxically, paralysis of the spinal extensors may cause either kyphosis or lordosis.

[3] *Gaz. des hôpitaux*, No. 75, 1902.

[4] *Lect. on Curv. of Spine*, 2nd ed. p. 64.

The spinal curvature in his case began in childhood, and was not the result of caries. The eldest son has proved to be the model of his father; the three next children are free from deformity, but the youngest child exhibited the spinal curvature even at an earlier date than his eldest brother." From the drawing of the cast given by Mr. Adams in his book, it is seen that the curvature affects the whole dorsal region, the natural convexity being greatly exaggerated. We have observed a similar instance in which a parent was affected in this way, and his son showed the bent back as early as the seventh year. It appears to us that very little can be done to remedy this condition. Constant lying down may be suggested by the medical attendant, but he will have a hard task to persuade the parents that such enforced abstinence from exercise and games by an otherwise perfectly healthy child is really needful to prevent deformity. At the onset of puberty the possibility of lateral curvature should be borne in mind.

III. Kyphosis of Adolescence—Round Shoulders, Faulty Attitude, and Flat Chest

In classifying alterations of the sagittal curvatures of the spine we might have dealt with :—

1. Changes in one portion of the spine secondary and compensatory to changes in another.

2. Changes in the spine secondary and compensatory to changes in extra-spinal parts, *e.g.* lordosis due to congenital dislocation of hip.

3. The reverse of 2, *e.g.* the alteration of pelvic inclination, and of the positions of the lower limbs to compensate for a spine ankylosed in a more or less total kyphosis.

Some such classification would impress the fact that the condition of one region of the spine, whether kyphotic or lordotic, can only be fairly dealt with as part and parcel of the attitude as a whole.

In describing elsewhere the antero-posterior curves of the normal spine we have pointed out that they vary with age, sex, and race;[1] they depend largely on, and are modified by the general muscular condition, and have to be adapted to meet such conditions as abdominal obesity and pregnancy.

It is clear, then, that it is not easy to describe any normal attitude, and the statements made are often vague and contradictory. The subject has been studied by, among others, the Webers, Meyer,

[1] In the aboriginal races the lumbar lordosis is less marked than in civilised types.

Horner, and later by Staffel, and more recently still by Schulthess and Lovett.[1] Lovett's researches, based on a very large number of observations, chiefly on normal young men and women, are especially valuable, and in the main his results agree with those of Schulthess and Staffel. Very briefly put, Lovett records on co-ordinate papers the relative positions of certain easily identified bony landmarks. He marks on the patient the positions of the mastoid process, the spine of the vertebra prominens, the spine of the seventh dorsal vertebra, of the fourth lumbar vertebra, the middle of the great trochanter, the middle of the head of the fibula, and the middle of the external malleolus.

"The apparatus by which the measurements are taken consists of the ordinary wooden upright, with a sliding arm used for measuring the height. On this sliding arm and at right angles to it is a horizontal arm, eighteen inches in length, which is placed at six inches from the back surface of the upright rod. This back surface of the upright rod is taken as the perpendicular plane from which variations are to be noted, and the measurements are made from the sliding horizontal arm, which is always six inches distant from the back surface of the upright. Any point, therefore, more than six inches from the sliding horizontal arm is in front of the perpendicular plane agreed on; any point less than six inches is behind it."

"The patient stands with the middle of the malleolus opposite the back surface of the upright, with his back toward the sliding horizontal arm."

From a comparison of the results obtained he finds that attitudes may be grouped under five types. For these Staffel's designations may be used. These are:—

I. *The normal attitude.*

II. *Faulty attitudes.*

(*a*) Round back.

(*b*) Flat back.

(*c*) Hollow back.

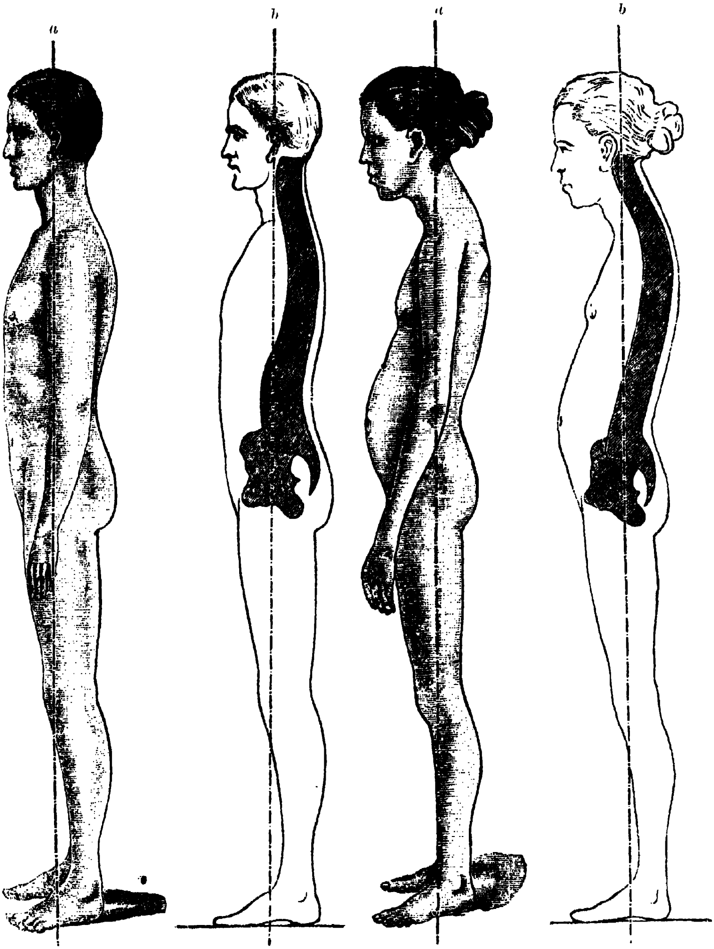
(*d*) Round hollow back.

I. In Staffel's normal attitude, with which Lovett agrees, a plumb line just clearing the sacrum barely touches the dorsal kyphosis,[2]

[1] Considerations of space will not permit us here to deal as exhaustively as is desirable with Lovett's work, and we must refer the reader to the very clear account in the *Trans. of the Amer. Orth. Assoc.* vol. xv., 1902, and his still more recent conclusions in *Lateral Curvature of the Spine and Round Shoulders*, 1907.

[2] According to Schulthess this is about the only "constant" of the normal vertebral column; but it does not apply to children. In them the line cuts the dorsal kyphosis.

neither the lumbar lordosis nor dorsal kyphosis being exaggerated or diminished. In this position (Figs. 419, 420) a vertical line

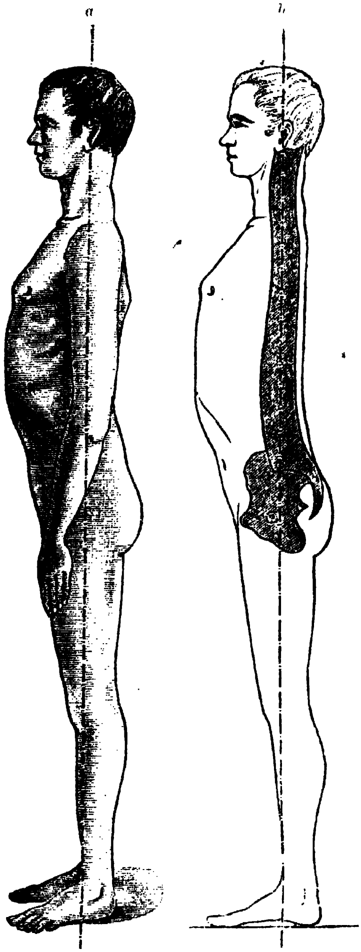


FIGS. 419, 420.—Normal Attitude (Staffel). FIGS. 421, 422.—Round Back (Staffel).

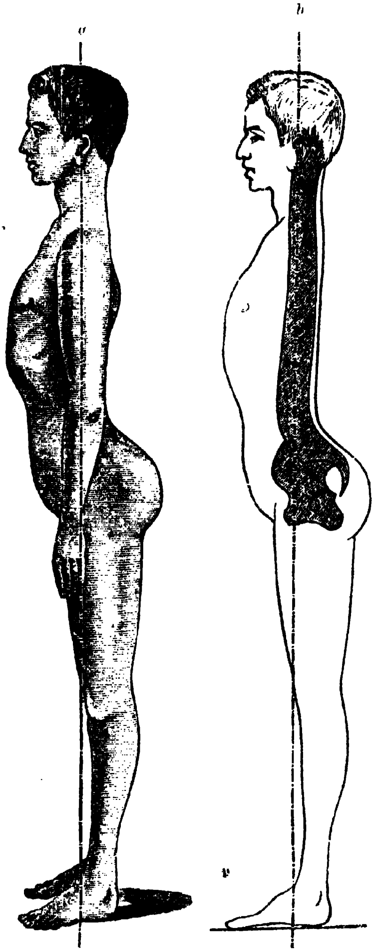
through the medio-tarsal joint crosses the ear and hip-joint, the pelvic inclination [1] being normal.

[1] We have repeatedly, *e.g.* in congenital hip, coxa vara, coxitis, observed how often an inclination of the pelvis greater than normal is associated with increased lordosis. No other factor has so great an effect on the shape of the spine as the degree of pelvic inclination. The reverse is also true, but is less often of importance. The normal angle of pelvic inclination varies considerably. Lovett regards above 65° or below 45°

II*a*. The "round back" (Figs. 421, 422). The dorsal kyphosis is somewhat exaggerated and encroaches on the lumbar and cervical



FIGS. 423, 424.—Flat Back (Staffel).



FIGS. 425, 426.—Hollow Back (Staffel).

regions. The cervical spine is inclined forward, carrying the head forward with it. There is no marked change in the lumbo-sacral

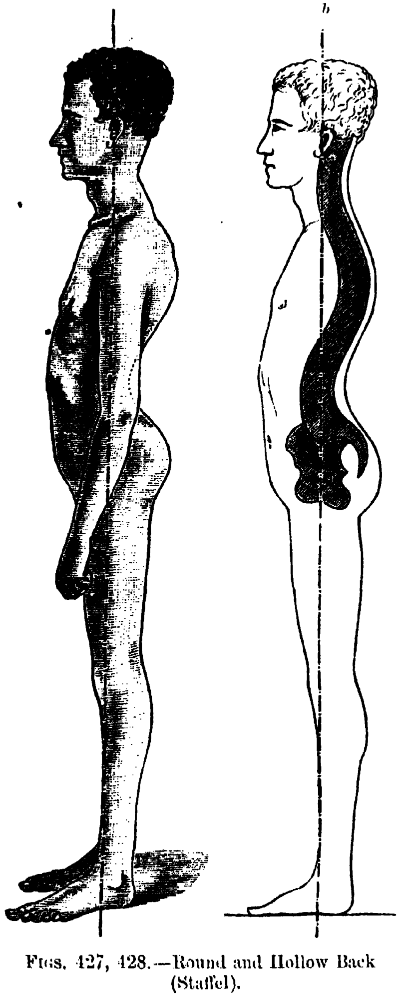
as pathological. He considers Prochovnik's methods of observation of the pelvic angle (*Archiv f. Gyn.*, 1882, xix. 1) as reliable, and accepts his averages as the most correct. These are 51·72° in males, 54·17° in females.

lordosis. The pelvic inclination is diminished, and the pelvis as a whole pushed forward. The legs, as a rule, incline forward, and are rarely hyper-extended at the knee. The vertical line through the medio-tarsal joint passes behind the hip-joint and ear, and the vertical line, just clearing the sacrum, passes well through the dorsal kyphosis. The thorax is thrown back, with the head and abdomen forward, so that there are flat chest, round back, and prominent abdomen.

II*b*. The "flat back." The lumbar lordosis and dorsal kyphosis are both diminished and the spine is more nearly straight (Figs. 423, 424).[1]

II*c*. The "hollow back." The pelvic inclination is increased and the pelvis as a whole is pushed backward. The sacro-lumbar angle is exaggerated, but the rest of the spine is nearly straight.[2] The knees may or may not be hyper-extended (Figs. 425, 426).

II*d*. The "round and hollow" back (Figs. 427, 428). The dorsal kyphosis is increased and so is the lumbar lordosis. The pelvis is normal or somewhat vertical, and the knees often hyper-extended. This variation[3] of "round" back is second in frequency. Schulthess considers it to be the result of insufficiency of the bones during the growing period.



FIGS. 427, 428.—Round and Hollow Back (Staffel).

It is rather difficult to say at times to what degree these variations approach a normal, or how far a given case is to be

[1] Lovett's type D. [2] Lovett's type C. [3] Lovett's type B.

regarded as pathological. The non-pathological variations are certainly considerable. Thus, taking sexual differences only, Lovett finds that in females "the individual variations are much greater than in the males, and there is a general tendency to carry the body farther forward, and to hyper-extend the knees—the lumbar curve also, as one would expect, being greater than in the males."

Practically what we have to decide is whether or not a given case calls for treatment.

Faulty attitudes in young adults and adolescents sufficiently marked to call for treatment. Round shoulders.—As we have said, the variations from the normal most usually met with in the young adult are in the first place the "round" back and then the round "hollow" back. Associated with these conditions, we see a forward displacement of the shoulder girdle, with the result that the scapulæ are displaced outward and assume a somewhat antero-posterior position with the angles unduly prominent.[1]

In short, round back and round shoulders may be regarded as one and the same.

As to the causation, we have already, under rickety spine, referred to the part played by rachitis, but in our opinion this does not account for the bulk of the cases. The round back attitude (Figs. 427, 428) is essentially that of muscular weakness. The pelvis is displaced forward, and the hips are extended, throwing the weight on to the ligamentous structures and relieving the muscles. Then again the infantile attitude is decidedly kyphotic, and many of these cases may be regarded as insufficient muscular development and delay in structural change. Doubtless, unsuitable school furniture, myopia, and the custom of wearing clothing suspended from the shoulders, all play certain but subsidiary parts. That muscular weakness or general insufficiency is the chief cause is confirmed by the configuration of most of these patients. Many of them are flat-footed and knock-kneed, while some eventually become scoliotic.

[1] Hasebroeck has suggested that certain of these cases of forwardly displaced or rounded shoulders may be explained by congenital shortening of the pectoral and serrati muscles. E. H. Bradford ascribes them "to a shortened condition of the ligaments and possibly an alteration in the joint surfaces in a certain direction." But it must not be forgotten that a high kyphosis gives rise to changes in the shape of the thoracic walls, on which the scapulæ rest. Cf. K. Hasebroeck, "Die Vorwärtslagerung des Schultergürtels als Haltungsanomalie in Beziehung zum runden Rücken." *Zeitschr. f. orth. Chir.* Bd. xii., 1903. And E. H. Bradford, "Round Shoulders," *Trans. Amer. Orth. Assoc.* vol. x.

The Flat Chest.—The ordinary form of flat chest is that seen associated with round shoulders depending on dorsal kyphosis. We have, in discussing the various thoracic deformities met with in caries of the spine, had occasion to point out how the direction of the ribs is modified by the position of the deformed spinal segments, and, on the direction of the ribs, the shape of the thorax depends. If the upper dorsal region is tilted forward, the ribs are sloped more acutely downwards, and a flattened chest results. The more the upper dorsal spine is pulled back, the more the anterior ends of the upper ribs are raised and the sternum rendered correspondingly prominent. Very similar, but to a less extent, is the state of affairs in ordinary flat chest. The dorsal kyphosis causes increased obliquity of the vertebro-sternal ribs. The sternum is depressed and flattened, and the thoracic cavity has its antero-posterior diameter diminished, while the vertical is increased.

In addition, according to Schulthess, the ribs, towards their anterior ends, are bent sharply inwards, thus increasing the flattening.

Apart also from the actual flattening there is a considerable amount of apparent flattening, due to the relative prominence of other parts. We have already referred to the forward displacement of the shoulders and altered position of the scapulæ, the prominent chin, the bent neck, and the protruding abdomen. The undue protrusion of these parts causes the flattened sternal region to appear more depressed than it really is.

The treatment is obvious, viz. to diminish the dorsal kyphosis by all available means, and to render the spinal curves normal, thereby raising the ribs. In addition to the usual spinal extension exercises and general drill, especial attention must be directed to breathing exercises, so as to mobilise the thoracic walls thoroughly, and to exercises which pull back the shoulders and stretch the contracted structures of the front part of the shoulder-girdle.

Treatment.—In the first place, the cause must if possible be ascertained and appropriate measures adopted. Myopia, unsuitable clothing, vicious attitudes, general weakness, require attention, and above all the individual must be taught to breathe properly. As to active treatment, Lovett divides cases into—

Non-resistant cases, capable of easy passive correction; and resistant, requiring forcible measures.

Non-resistant cases may be treated by gymnastics and general "setting-up drill," and extension exercises for the back which we have discussed under scoliosis.

Resistant cases are forcibly stretched by means of a special frame designed by Lovett,[1] or one of the appliances used for forcible correction of scoliosis may be adapted. Intermittent correction only may be sufficient to mobilise the spine, or it may be advisable to correct forcibly and apply a plaster jacket. Subsequent treatment is partly gymnastic and partly the use for a time of an appropriate spinal support to prevent relapse.

REFERENCES

WEBER, M. and E. Mechanik der menschlichen Gehwerkzeuge. Göttingen, 1836.
MEYER. Die Mechanik des Sitzens. Virch. Archiv, Bd. xxxviii., 1867.
MEYER. Die Statistik und Mechanik des menschlichen Knochengerüstes. Leipzig, 1873.
STAFFEL. Die menschlichen Haltungstypen und ihre Beziehungen zu den Rückgratsverkrümmungen. Wiesbaden, 1889.
SCHULTHESS. Article in Joachimstal's Handbuch.
GOLDTHWAIT. Amer. Jour. Orth. Surg., August 1903.
BRADFORD, E. H. References given above.
LOVETT. References given above.
HASEBROECK. References given above.

Arrangement of Clothing.—The fashion is to suspend in a girl the petticoats and other under-garments from braces passing over the shoulders. But the mischief is that the braces are so made as to press near the tips of the shoulders, and increase the drooping forwards of these parts. The braces should pass near the root of the neck, and in order to keep them in that position they should be joined together by a transverse piece of webbing. The best arrangement for most children is to have a belt made of webbing or other strong material about an inch wide, and from this the under-garments are suspended. To this belt the braces are attached. Goldthwait[2] suggests in severe cases that the following arrangement be tried: A band of webbing, one inch wide, passes horizontally across the back at the level of the spine of the scapulæ, and each end is then brought forwards beneath the axillæ and over the front of the shoulders, and then passes diagonally across the back, so that one lies over the other. Where they cross in the middle of the back they are sewn together. To the ends of the strap the clothes are fastened.

The kyphoses of adult life will be found described in the articles dealing with the special conditions causing them.

[1] Cf. R. W. Lovett, *Lateral Curvature of the Spine and Round Shoulders*, fig. 182.
[2] *Amer. Journ. Orth. Surg.* vol. i. No. i. p. 65.

Occupation Kyphosis.—*In adult life* the causation of kyphosis in tailors and cobblers is sufficiently obvious, and may almost be considered a trade-mark. Nor is it confined to them; the use of the bicycle has induced the "bicycle-stoop," and we have frequently seen kyphosis in mountain-porters in Switzerland.

Mr. W. Arbuthnot Lane[1] has most convincingly shown that many cases of posterior excurvation of the spine associated with spondylitis are due to pressure on it, either from the nature of the labour being such as to induce long-continued strain ("labour changes"): or from the pressure of adjacent bodies on the intervertebral discs, arising from faulty position of the patient, and causing their partial absorption, together with profound alteration in the shape of the bodies and the structure of the ligaments.

Senile kyphosis is the result of debility and wasting of the tissues, with absorption of the intervertebral discs. The same change is brought about by the nature of the occupation, as in agricultural labourers and in those whose vocation is such as to produce continual fatigue of the spinal muscles, notably in those "who live by the pen." W. Adams observed a severe form of kyphosis in old cavalry officers who have seen a great deal of service in India, and he attributed it to the fatigue of frequent and long marches. In many cases the natural stoop of old age is hastened by rheumatoid affections of the vertebral articulations. In the most severe forms of senile kyphosis the body is bent at a right angle, and the patient can walk only with the assistance of sticks. Such cases suffer very severely from difficulty of breathing, dyspepsia, and interference with the normal action of the heart, as evidenced by persistent palpitation. Beyond careful attention to the position assumed when writing or reading, the avoidance of undue fatigue, and daily exercise with light dumb-bells as preventive measures, very little can be done. When the curve has once formed, efforts must be made to prevent its becoming more exaggerated by attention to the points just alluded to.

[1] *Guy's Hosp. Rep.*, 1886, 1887, p. 278; and 1885, p. 321. See also *Path. Soc. Trans.* vols. xxxvi. and xxxvii.; and *Med.-Chir. Trans.* vol. lxvii.

CHAPTER VIII

LORDOSIS

Lordosis, Physiological and Pathological—Compensatory, Static, Paralytic, and Spasmodic—Lordosis in Scoliosis and Caries of the Spine—Treatment.

WE have already, in discussing kyphosis and faulty attitude in general, practically disposed of the question of lordosis.

Lordosis, whether physiological or pathological, may be regarded as a compensatory condition. The normal sacro-lumbar lordosis is an essential factor in the assumption of the erect position. As we have stated, the position of the lower limbs, the degree of the pelvic inclination, and the sacro-lumbar lordosis, are intimately connected.

Lordosis, like kyphosis, and indeed like all biological characteristics depending on phylogenetic considerations, varies with age, sex, and race. These variations will be found referred to in the preceding article. The lumbar region of the spine in females is relatively longer than in males, and, on the whole, more incurved. How much is due to increased lumbar lordosis, and how much is due to a sharper lumbo-sacral angle, has not been definitely decided. Increased lordosis occurs normally in the lumbar region in the women of some races, notably in those of Cuba; and it is present in women advanced in pregnancy, and when the abdomen is distended by fat, ascitic fluid, or ovarian tumours.

Lordosis is normal in certain regions of the spine, and may be merely exaggerated, as in certain faulty attitudes, or increased, so as to compensate the greater pelvic inclination, as in congenital hip disease. And in all these instances the dominant fact is compensation. It is rather difficult to give examples when the lordosis is not compensatory, but intrinsic. Still, a few such exist. Thus in some cases of rachitic scoliosis we meet with an acute lordosis due to bony softening. Spondylolisthesis is essentially a local lordotic condition, and the lordosis of infantile paralysis is not

always secondary to kyphosis elsewhere. So that the lordotic conditions most generally met with are merely exaggerations of the normal lordosis, as in pseudo-hypertrophic paralysis, and are limited to the same regions of the spine.

However, we may, and do occasionally, see lordosis of regions normally kyphotic. Thus in certain scolioses the normal curves are reversed, and in lumbar caries, with extreme kyphosis in that region, the dorsal spine may be distinctly lordotic.

A total lordosis can hardly exist. In certain cases of acute convulsions, in which the patient rests on head and heels, it would seem as if total lordosis was present. But, it must be remembered that the normal dorsal kyphosis cannot be made to disappear entirely in hyper-extension of the spine, and in the rare cases mentioned above the dorsal lordosis is the outcome of prolonged structural adaptation to extreme kyphotic changes elsewhere.

It may be useful to classify the lordosis met with as—

I. *Total.*—The existence of this form is very doubtful.

II. *Partial.*

A. Exaggeration of curve in regions normally lordotic.
- (*a*) Compensatory to kyphosis.
- (*b*) Compensatory to increased pelvic inclination.
- (*c*) Static, *e.g.* in abdominal obesity.
- (*d*) Paralytic.
- (*e*) Spasmodic.
- (*f*) Rachitic.

B. Reversal of a normally kyphotic curve.
- (*a*) In certain scolioses.
- (*b*) In some cases of caries of spine.
- (*c*) Osteomalacia.

We have shown elsewhere (vol. ii. sect. xi.) how paralysis of the spinal muscles causes lordosis. As an interesting example of spasmodic lordosis, we may allude to those cases occurring in infants where the head is retracted, the posterior cervical muscles are rigid, and the back is generally incurved. The condition is probably reflex, and due to injudicious feeding, and is relieved by a smart purge and change of diet. The interest of this type lies in the fact that in debilitated infants the lordosis is sometimes thought to be a symptom of the onset of tuberculous meningitis.

The *treatment* of lordosis depends upon its cause. In the

majority of cases very little can be done beyond alleviation, if possible, of the underlying condition. In Pott's disease, after ankylosis has occurred, no interference with the lordosis is justifiable. The lordosis of rickets calls for general treatment, for support whilst the muscles remain weak, and for massage so as to improve their tone.

CHAPTER IX

COXA VARA, TRAUMATIC SEPARATION OF THE EPIPHYSIS OF THE NECK OF THE FEMUR

General Considerations—Angles of Inclination, Declination, Alsberg's Angle—Coxa Vara, Definition, History, Nature, Ætiology, Causation, Varieties, Symptoms, Pathology, Diagnosis—Treatment—Traumatic Separation of the Epiphysis of the Neck of the Femur, and Fracture.

Coxa Vara

General Considerations as to the Position of the Parts.—In the normal adult the angle of the neck of the femur, called also the angle of inclination, that is, the angle made by the long axis of the neck and the long axis of the shaft, is about 130°; and it is found in many normally constructed people that the angle is rather less than this. In a few the angle exceeds this figure slightly. Observers have not come to a definite agreement as to what is exactly the normal angle of inclination, doubtless because it varies slightly in adults according to the height, sex, width of the pelvis, muscular development, and racial characteristics. As the mean of a large number of measurements, 128° to 132° may be accepted as the normal condition. In childhood it is a few degrees more, in old age a few degrees less, than in adults. In Fig. 429 the angle CEB is the angle of inclination.

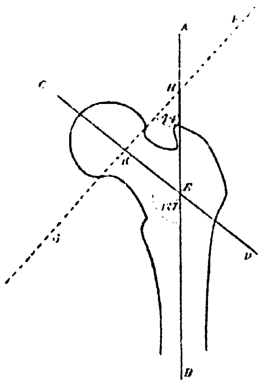


Fig. 429.—Diagram of Upper Third of Normal Femur. CEB, Angle of Inclination; GHB, Alsberg's Angle.

Under abnormal conditions this angle may be considerably increased (coxa valga); or, as is more frequently the case, it is

considerably diminished (coxa vara). Now, if the angle of the neck is much decreased, abduction of the femur is interfered with or actual adduction is present.

When change of form in a part leads to adduction of the segment of the limb beyond the deformity, orthopædic surgeons speak of it as a varus condition. In accordance with this convention, if changes in the femoral neck cause adduction of the shaft the condition is known as coxa vara. The reverse condition, in which the angle is increased, and the neck and shaft are more in line, is known as coxa valga.

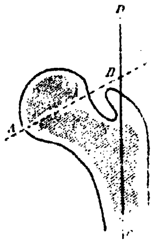


FIG. 430.—Diagram of Upper Third of Normal Femur. AB, Hoffa's line or epiphysial line; ABC, Hoffa's angle.

The pathological conditions actually met with are not so simple as the terms adduction or abduction suggest, but still, the use of the expressions coxa vara and coxa valga has been of the greatest service in drawing close attention to these cases. It is at once obvious that, congenital cases apart, the chief factor influencing the shape of the neck of the femur is the superincumbent body-weight, and if the neck be absolutely or relatively weak from any cause, whether pathological or traumatic, it will yield at the weakest spot.

The chief distortions are:—

(A) At the base of the neck and its junction with the shaft, the *coxa vara trochanterica* of Fröhlich. As may be anticipated, such a condition is rare, because the neck is broadest and strongest at its origin from the shaft.

(B) The whole neck may be involved, the "cervical" coxa vara of Whitman, and its axis is then represented by a curved line.

(C) The deformity is best marked at that part of the neck near the head, the "epiphysial" form of Whitman.

In (B) and (C) measurement of the angle made by the neck with the shaft, or the angle of inclination, is no criterion of the extent of the distortion present. What is required is the measurement of the position of the head in relation to the upper portion of the shaft. Alsberg obtains this by drawing a line (Fig. 429) through the base of the head where the cartilaginous covering ceases, and notes the angle which this line makes with that of the long axis of the shaft prolonged upward. Normally Alsberg's angle (Richtungswinkel) is about 41°. In coxa vara it is less, in coxa valga greater. When the neck of the femur

PLATE XXV.

Radiogram of a case of Unilateral Coxa Vara. The Neck of the Left Femur is generally curved; "Cervical Coxa Vara" of Whitman.

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is so depressed that Alsberg's line (Fig. 429) cuts the long axis below instead of above, the measurement is given in minus quantities. Unfortunately the measure is of little use in the living subject. If the approximation of the head to the shaft depends

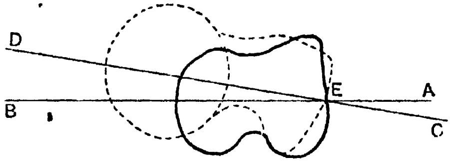


FIG. 431.—To illustrate the Angle of Declination. Diagram of the Upright Right Femur seen from above. The dotted line represents the Outline of the Head and Neck, the continuous line the outline of the Condyles; AB, transverse axis of Condyles; CD, axis of Head and Neck; DEB, angle of Declination.

upon curvature of the upper portion of the diaphysis the case is termed "false" coxa vara.

So far we have regarded the femur as viewed directly from the front, that is, in section in the frontal plane of the body. But if we look at the upper end of the femur from above, the long axis of the neck makes an angle of 12° (sometimes called the angle of

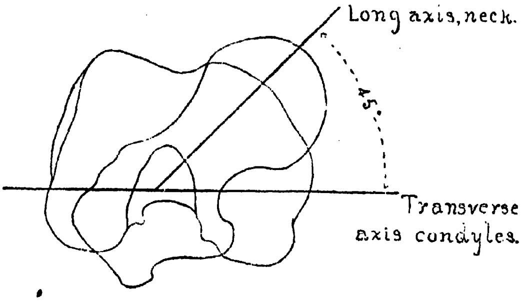


FIG. 432.—The Left Femur seen from above. Great Increase of the Angle of Declination (Bradford and Lovett).

declination) with the transverse axis of the knee joint (Fig. 431); for the neck and head are normally directed somewhat forwards. In coxa vara the head is usually displaced backwards, the anterior border of the neck becoming convexly curved; in fact, in some parts this convexity may be actually demonstrated by palpation. Finally, there may be torsion of the neck on its long axis, Figs. 433 to 436, a factor difficult to estimate and impossible to

measure. In practice we have to depend upon the severity and character of the symptoms and on skiagraphy (Plates XXV., XXVI.).

Definition.—Coxa vara, then, is the term applied to a condition in which the neck of the femur is bent downward sufficiently to give rise to symptoms. The bending may be unilateral or bilateral.

History.—Fiorani,[1] referred to by Müller,[2] described curvature of the femoral neck as occurring in fifteen cases of rickets. The adolescent form was first described in 1889 (Hofmeister says 1888) by E. Müller under the title *Die Verbiegung des Schenkelhalses in Wachstumsalter.* His attention was first drawn thereto by a

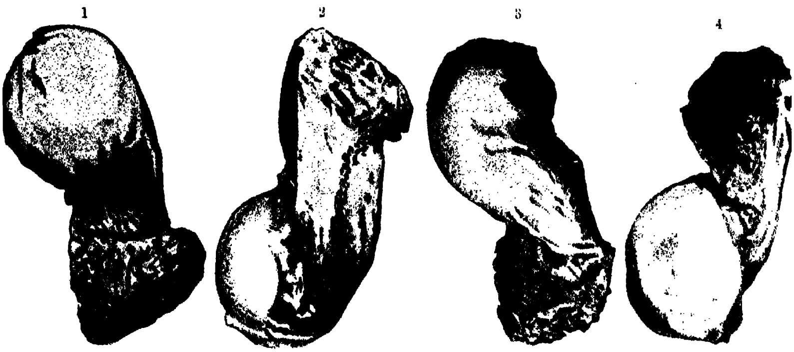


FIG. 433. FIG. 434. FIG. 135. FIG. 436.

Coxa Vara showing the Deformity of the Head and Neck of the Femur (Spencer and Gask, after Kocher). 1. Posterior View, Left Side. 2. Anterior View, Left Side. 3. Posterior View, Right Side. 4. Anterior View, Right Side. The neck is bent downwards to a right angle with the femur, also backwards, whilst it is twisted on its axis, so that the articular surface, instead of looking upwards and inwards, looks downwards and backwards.

specimen[3] obtained from a resection undertaken for a supposed coxitis. To this day many cases of coxa vara are mistaken for hip-joint disease. Müller was able to add three others[4] to this case, and he described the clinical appearances. Before Müller's time single specimens, such as that of Richardson,[5] had been recorded; and from time to time descriptions of what were evidently cases of

[1] "Sopra una forma speciale di zoppicamento," *Gazz. degli ospedali*, 1881.

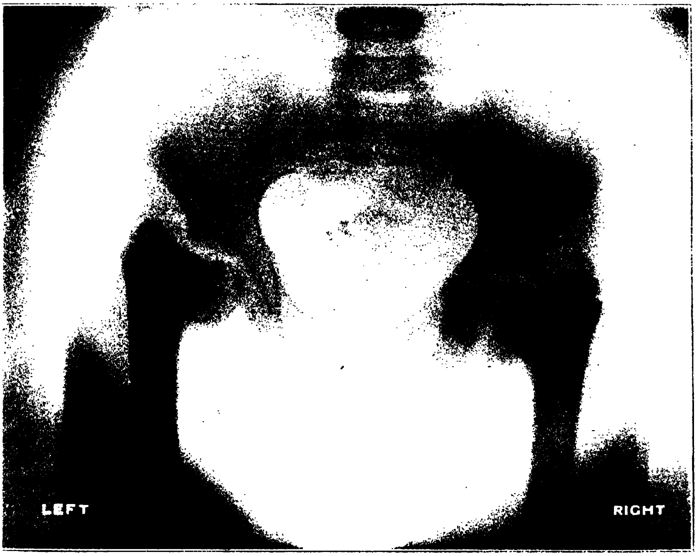
[2] *Centralbl. f. Chir.*, November 27, 1897.

[3] See fig. 237, p. 378, Joachimstal's *Handbuch der orth. Chir.* Parts vi. and vii.

[4] *Beiträge z. klin. Chir.*, 1889, Bd. iv. section 137.

[5] "Deformity of the Neck of the Thigh Bone, simulating Fracture, with Ossific Union," *Transac. Philad. Pathol. Soc.*, 1857.

PLATE XXVI.



Radiogram of an Extreme Case of Bilateral Coxa Vara

To face page 578.

coxa vara appeared in literature, for example, those of Monks[1] and C. B. Keetley.[2] The interest attaching to Keetley's case is that he adopted treatment which cannot be improved upon to-day, although he did not apparently recognise the essential nature of the affection, but rather regarded it as part of a widely spread disorder. In 1894 Kocher[3] and Hofmeister[4] simultaneously suggested the name coxa vara, although they do not use it quite in the same sense. Since 1894 the literature of the subject has become so extensive that it is impossible here to give a complete bibliography. Carl Helbing[5] gives a list embodying 202 references, though even this is by no means complete. In connection with traumatic coxa vara the name of Royal Whitman occupies a prominent place.[6]

Nature of the Deformity.—As we have stated previously, the changes may be most marked at the trochanteric end of the neck (coxa vara trochanterica), or at the junction of the neck with the head (the epiphysial form). We may now describe more fully the various types of bending of the neck, and give them in their order of frequency.

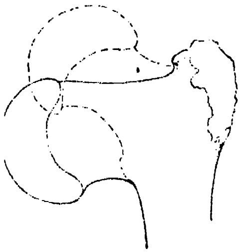


FIG. 437.—Coxa Vara. Outline of the depressed neck of the femur in Müller's specimen, contrasted with the normal position as shown by the dotted line (Royal Whitman).

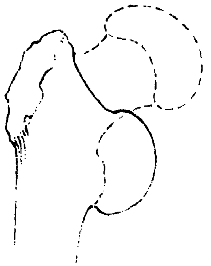


FIG. 438. — Coxa Vara. Outline of the deformity in Hoffa's specimen. The dotted line shows the normal position (Royal Whitman).

1. The neck of the femur is bent downward and backward, the convexity looking forward and upward. The majority of cases are of this type. The result of the distortion is that abduction is lessened (Fig. 439), the leg is rotated outward, and the foot everted. The trochanter is also elevated, flexion is limited, while

[1] "Case of Unusual Deformity of both Hip Joints," *Boston Med. and Surg. Journ.*, Nov. 18, 1886.

[2] *Illustrated Med. News*, Sept. 1888, "A Case of Rachitis Adolescentium."

[3] "Über Coxa Vara, eine Berufskrankheit des Wachstumsperiode," *Zeitschr. f. Chir.* Bd. xxxviii.

[4] "Coxa Vara, eine typische Form der Schenkelhalsverbiegung," *Beiträge z. Klin. Chir.* Bd. xii.

[5] *Zeitschr. f. orthop. Chir.* Bd. xv. Hefte 2 bis 4, 1906, pp. 624 to 631.

[6] *New York Med. Rec.*, July 25, 1893; *Ann. of Surg.*, June 1897, Feb. 1899, and Nov. 1902; *Med. News*, Sept. 24, 1904.

adduction, outward rotation, and extension may be increased. In consequence of this downward and backward bending of the neck (convexity forwards) the position of the head of the femur in the acetabulum becomes altered, so that above and in front a greater part of the neck becomes situated under the acetabular margin; whilst at the lower and back part of the joint a correspondingly greater part of the head has escaped from the socket.[1] While we can understand the cause of the downward bending, the backward twisting of the head is difficult of explanation. It may be due to the pull of the strong posterior pelvi-trochanteric muscles. Kocher[2] puts it down to the body-weight, and Mainz agrees with him. It is conceivable that in a man habitually working with a bent back, a flexed hip, and bent knee, the neck of the femur would eventually yield and acquire a forward convexity.

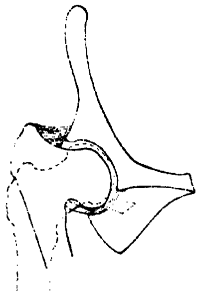


FIG. 439.—A cross-section of the Pelvis and Varoid Neck of the Femur. A scheme to show the effect of the deformity in limiting abduction of the limb. The effect of abducting the shaft of the femur on the elevation of the Head of the bone after osteotomy is also seen. The dotted outline shows the normal relationship of the parts (Royal Whitman).

2. A downward bending only. In these cases neither inversion nor eversion of the limb are marked. There is a little loss of flexion, but abduction becomes more and more limited.

3. Depression of the head of the femur, with bending of the neck, so that its convexity is backward. In this event rotation outward is impeded and the foot and leg are inverted.

4. Kocher[3] demonstrated a condition in which there is a torsion of the neck on its long axis, so that the shaft appears to be hyper-extended in relation to the head (cf. 433 to 436).

5. Löwenstein has demonstrated in a preparation the existence of convexity of the neck forwards without simultaneous depression.

6. In exceptional cases there may be bending of the upper part of the shaft of the femur. This is sometimes termed "false coxa vara."

[1] Alsberg speaks of this as subluxation, and says it is seen very clearly in specimens where the posterior and under part of the head is no longer in contact with the cotyloid cavity and the cartilage is thin and atrophic, the limit being marked with a sharp line.

[2] Joachimstal's *Handb. f. orth. Chir.* p. 284.

[3] *Ibid.* p. 377.

The groups of immediate practical interest are 1 and 2. The other conditions are rare.

Occurrence and Ætiology.—Whitman[1] gives a list of 54 cases under his care; Helbing, in connection with Hoffa's Clinic, mentions 77, and Hofmeister over 100—so that the affection is not rare; and the more Röntgen rays are employed, the more frequently will it be recognised and differentiated from coxitis and congenital dislocation.

The affection is unilateral or bilateral, and males are affected more often than females because of the more laborious nature of their work. It is seen in growing bone, and most often in adolescents, because they undergo greater strain than children, and the neck of the femur is relatively longer (Whitman). Kirmisson[2] does not agree that coxa vara is more prevalent in adolescents.

According to the time of onset we may speak of *coxa vara congenita*, *infantum*, *adolescentium*, and *adultorum*, and to a considerable extent this classification is ætiologically justifiable.

When the affection is unilateral, the left leg is more often affected than the right, possibly because more weight is thrown on this side in the stand-at-ease position.

The **Causes** of coxa vara are found in one of two conditions, either increased strain on or diminished resistance of the neck of the femur. It is quite easy to understand why the neck of the femur should give way in any well-marked general process of bony softening, such as results from osteomalacia or local inflammatory foci of tuberculous or osteomyelitic origin. Traumatisms, such as fracture, partial or complete, or epiphysial separations, afford in some cases a sufficient explanation, but in the static cases there is no condition, either local or general, to fall back upon. The history, the method of onset of the affection, its chief features and its analogies with static flat foot, genu valgum, and ordinary scoliosis, show that we are dealing with a relative weakness of the femoral neck.

Varieties.—We may classify coxa vara thus:—

A. Congenital coxa vara.

1. With no other deformity present.
2. Associated with congenital dislocation of the hip, or some other deformity.

[1] *Treatise on Orthop. Surg.* 2nd edit. p. 538.
[2] *Difformités acquises*, Paris, 1902, p. 388.

B. Acquired Coxa Vara.
1. Essential coxa vara—static or adolescent.
2. Symptomatic coxa vara.
(*a*) Traumatic.
(*b*) Due to non-inflammatory processes.
(*α*) Rickets.
(*β*) Osteomalacia.
(*γ*) Senile osteoporosis.
(*c*) Due to inflammatory processes.
(*α*) Osteomyelitis.
(*β*) Tubercle.
(*γ*) Arthritis deformans.
(*d*) Traumatic causes, such as fracture of the neck of the femur and epiphysial separation.

To these Hofmeister adds *coxa vara neurotica*, occurring in syringomyelia, and coxa vara in athyrosis or cretinism. We shall deal with these varieties in their order, but the majority of them do not call for extended treatment.[1]

Congenital Coxa Vara

This was first described by Kredel,[2] and cases have been recorded by Joachimstal,[3] Reiner,[4] Drehmann,[5] and others. Hoffa has called attention to it, and Helbing gives records of twenty-two cases from Hoffa's Clinic.[6] In these, coxa vara was the only anomaly present in seventeen, being unilateral in nine and bilateral in eight cases. In four it was associated with congenital dislocation of the hip-joint. In some instances it was associated with marked defective development of the upper end of the femur, and in others with various congenital anomalies.

The **Symptoms** are a waddling gait, lumbar lordosis, elevation of the top of the trochanter above Nélaton's line, adduction of the limb, more or less marked, and some rotation outward. On kneeling,

[1] Another method of classification is worthy of mention :—I. Congenital ; II. Infantile or rachitic ; III. Adolescent ; (*a*) Essential or static ; (*b*) Traumatic ; (*c*) Symptomatic ; (1) of late rickets ; (2) of juvenile osteomalacia ; (3) of arthritis deformans ; (4) of inflammation ; *α*, tuberculous ; *β*, osteomyelitic.

[2] *Centralbl. f. Chir.* No. xlii. 1896.

[3] *Arch. f. Gynäcol.* Bd. lxv., and *Zeitschr. f. orth. Chir.* Bd. xii. Hefte 1 and 20, p. 52.

[4] *Zeitschr. f. orthop. Chir.* Bd. ix.

[5] *Verhandl. d. deutschen Gesells. f. orth. Chir.* i., Kongress 1902.

[6] *Zeitschr. f. orth. Chir.*, 1906, Bd. xv.

the legs are crossed (Fig. 443); and the patients sit Turkish fashion, and perhaps lie in bed with the limbs in complete rotation outwards, like "decapitated frogs" (Schede). Skiagraphy shows that the head does not fill the upper part of the acetabulum, and the naturally short neck of the femur is depressed to a right angle or less. The epiphysial line is broadened and irregular, and it is vertical and not oblique as in rickets (Figs. 440, 441).

The condition is very apt to be mistaken for congenital dislocation of the hip.

We do not know the cause of congenital coxa vara, but Francke[1] in a family of four children found three to be affected with it on both sides, the youngest being one and three quarter years old. In the last child the effect of the body-weight could have had little influence in producing the deformity. The association of coxa vara and congenital dislocation is now well known. It is important to bear it in mind, because it may constitute one of the causes of failure in reducing dislocation, by preventing full abduction. This latter variety of coxa vara is not necessarily primarily congenital, but it may be static. Since, however, it has been seen by Hoffa as early as one and a half years of age, it is unreasonable to suppose that over-weighting of the part accounts for all the cases.

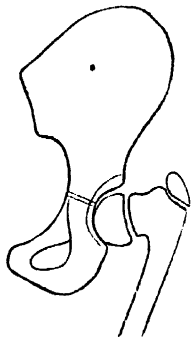


FIG. 440.—Congenital Coxa Vara, showing the nearly Vertical Line of the Epiphysis of the Neck (Hoffa).

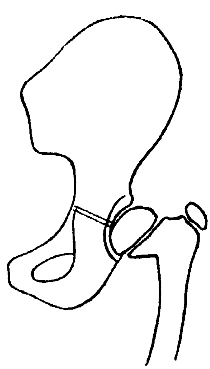


FIG. 441.—Rickety Coxa Vara. The Line of the Epiphysis of the Neck is very oblique (Hoffa).

The treatment of these cases is to be conducted on the general principles to be presently laid down.

ACQUIRED COXA VARA

Essential Coxa Vara.—The essential or static variety is nearly always an adolescent condition, and most of the cases originate between the ages of thirteen and seventeen years, though a few

[1] *Verhandl. d. deutschen Gesells. f. orth. Chir.*, ii. Kongress 1903.

begin before and after that time. In Royal Whitman's list[1] of twenty-three cases, eighteen were males. The left limb was affected eleven times and the right nine times.

Symptoms.—They are shortening, adduction, limitation of abduction, with rotation outward, and prominence of the trochanter.

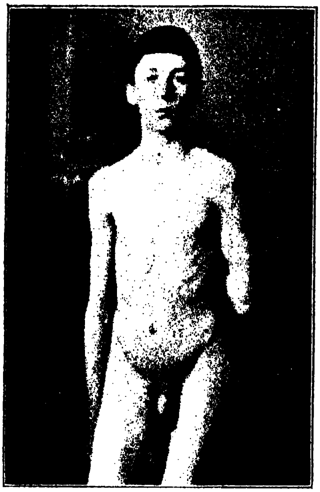


FIG. 442.—Left Coxa Vara. Great Prominence and Elevation of the Trochanter.

FIG. 443.—Bilateral Static Coxa Vara, showing the Involuntary Crossing of the Limbs when kneeling (Joachimstal).

In unilateral cases the patient walks with a limp, and in bilateral cases waddles and has lordosis. On examining him from the front the great trochanter is seen to be prominent, partly on account of the elevation of the processes, and partly because of the muscular atrophy (Fig. 442). In unilateral cases the shortening, which is real, may amount to two, or even two and a half, inches. Apparent shortening, which is also present, is due to the tilting upward of the pelvis on the affected side to compensate for the adduction. A measurement taken from the top of the great trochanter to the internal malleolus on one side, and compared with the sound side,

[1] *Orth. Surg.* 2nd edit. p. 538.

shows no shortening, thus making it clear that the loss in length of the limb is due to a change in the position of the head of the femur. In bilateral cases, elevation of the trochanters (Fig. 445) can be appreciated by marking out Nélaton's line. On active movement, adduction is free but abduction is interfered with or impossible. In those cases where, in addition to downward depression of the head, there is a convexity forward of the neck, eversion is present, and

FIG. 444.—Bilateral Coxa Vara. Involuntary crossing of the Legs on flexing the Thighs on the Body (Royal Whitman).

FIG. 445.—Bilateral Coxa Vara, showing the Prominence and Elevation of the Great Trochanters (Royal Whitman).

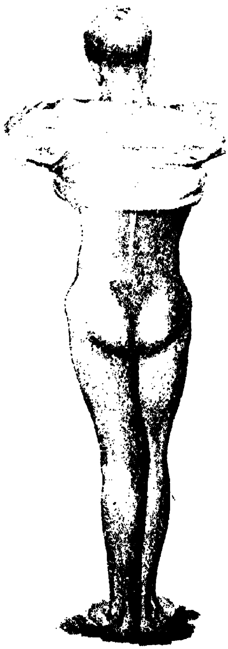


FIG. 446.—Back view of Patient in previous figure, showing the Relative Prominence and Elevation of the Trochanters, and the Absence of the Normal Lumbar Lordosis (Royal Whitman).

rotation inward is limited. When the convexity of the neck is backward the reverse occurs. Flexion is as a rule little interfered with; it is, however, accompanied in the majority of cases by rotation outwards. It is impossible in bilateral cases for the patient to sit down and place his thighs parallel unless he crosses his legs at the same time, and according to Joachimstal he can only kneel with the legs crossed (Fig. 443). If marked adduction is present, simultaneous flexing of both hip and knee joints evokes a very characteristic posture (Whitman) (Fig. 444). If the patient is viewed from the back the prominence of the trochanters, muscular atrophy, and the elevation as it were of the femoral shafts, together with the eversion of the limbs, are well seen (Figs. 445, 446). In many cases Trendelenburg's symptom can be elicited.[1]

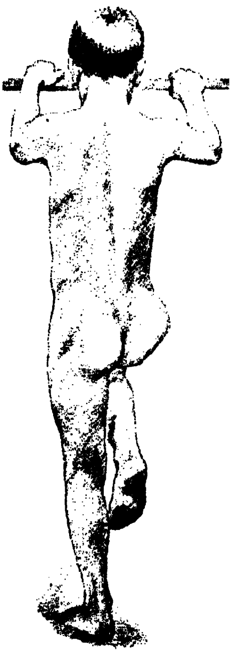


FIG. 447.—Unilateral Coxa Vara, showing the Effect of Flexion of the Thigh in increasing the Deformity (Whitman).

At the onset of the affection the patient complains of vague pains in the hip and knee; he becomes quickly tired and walks with some difficulty, or even limps. In some cases, especially after exceptional exertion, the part becomes very painful, and muscular contraction may be seen. As in coxalgia, Elmslie[2] states that "all cases of adolescent coxa vara pass through a stage of immobility of the hip-joint, which may last a long or short time." With this statement the author cannot agree.

Pathology of the Essential Form.—To explain the onset various conditions[3] have been cited, such as late rickets, juvenile osteomalacia and osteomyelitis, but attempts to demonstrate their presence have not been successful. The existence of late or recrudescent rickets is doubted by many, and very few cases of this form of coxa vara show any signs of former rickety attacks.

[1] Trendelenburg's sign is this: If the patient stands on the affected limb and flexes the hip of the sound side, so as to raise that foot off the ground, the pelvis slips downwards on the sound side, because the (weakened) abductors of the hip on the affected side are unable to brace the pelvis on that side.

[2] *Lancet*, Feb. 1907.

[3] Hohmann, *Münch. med. Wochenschr.*, June 7, 1910, lvii. No. 23.

In the adolescent variety the bending usually takes place near the epiphysial line, but not so often as in the traumatic form. The head is depressed downward and outward from its normal position, so that it is abducted, and it is subluxated over a considerable portion of its under surface, which is no longer in contact with the acetabulum. To this fact some of the disability in movement is due, but another cause in severe cases is the impact of the upper border of the neck of the femur against the edge of the acetabulum. This is particularly so when there is a prominence or spur[1] on the upper

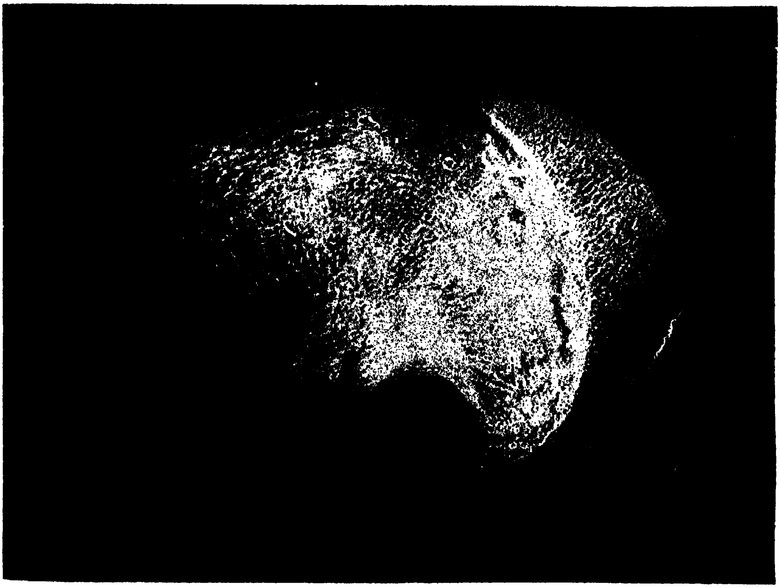


FIG. 448.—Static Coxa Vara (Hofmeister).

border of the neck (Fig. 449), which at once limits abduction. Other causes of the loss of this movement are the adduction of the shaft of the femur with the sequential structural shortening of the adductor muscles. It is striking to notice that with the change in the directions of the shaft and the neck, the upper border of the latter becomes much lengthened. Normally the trochanter is about

[1] Elmslie, in radiographs of twenty cases of adolescent coxa vara, found this spur to be present, and takes it to indicate that the epiphysis has slipped from its normal position. In one case of Ramstedt's there was an area of cancellous bone laid bare by the slipping of the epiphysis.

an inch away from the head, but in coxa vara it may be as much as two and a half inches.

In this form of coxa vara the head of the femur is depressed to the right angle or less, and it may even be forced into the neighbourhood of the small trochanter. At the same time that the head is depressed, owing to vertical bending of the neck, a curvature of the latter in a horizontal plane takes place in some cases, so that it is convex anteriorly. In other cases the neck is merely bent down-

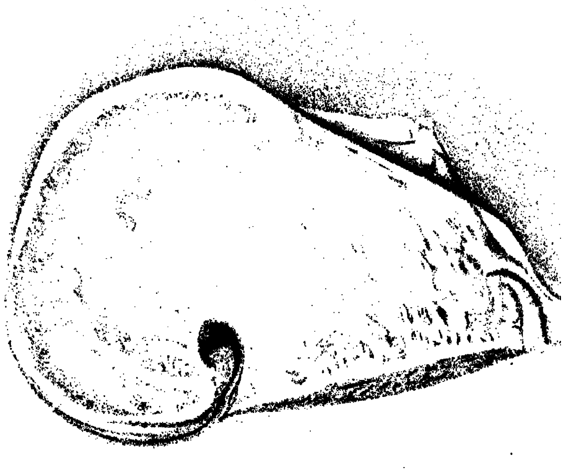


FIG. 419.—Static Coxa Vara (Hadke).

Note the peculiar downward folding of the head and neck.

ward. In yet others the neck is convex backwards, and in very rare cases torsion of the neck alone is present. As to the causes of the forward or backward convexity of the head no direct evidence is forthcoming.

Differential Diagnosis.—As a rule no difficulty exists, particularly if a skiagram can be obtained.[1] In this variety congenital dislocation may be excluded by the age of the patient and the history of the affection. The differentiation of coxitis from coxa

[1] The fallacies in skiagrams are referred to more fully when we deal with coxa valga (p. 626).

vara may be easy or may be temporarily impossible, if the case is seen during the period of spasm, fixation, and pain, the *coxa vara contracta* of Hofmeister. Fortunately, the treatment is the same in both cases, namely, rest and extension. In typical cases of either affection no confusion can arise. In every case of suspected coxa vara, a Röntgen ray photograph should be taken.

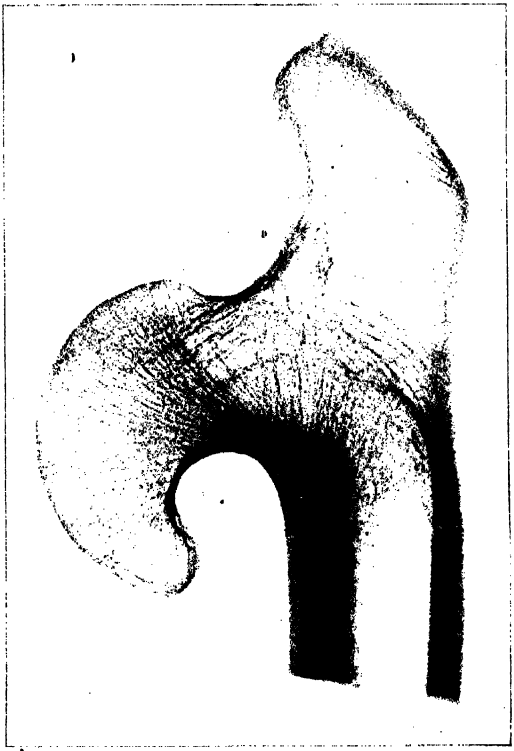


FIG. 450.—The upper third of a femur from a case of Bilateral Coxa Vara, most probably Static in origin and occurring in an adolescent (Jordan).

As to whether a given case is static or traumatic it is sometimes unwise to dogmatise. Indeed many are borderland cases, and some may be regarded as the result of slight and apparently insignificant traumatism occurring in a patient with a weakened or softened neck of the femur.

Treatment of the Adolescent Form.—When the diagnosis has been made, much discrimination should be used in the selection of

the measures to be carried out. If the case is an early and slight one, and dependent upon the nature of the occupation of the patient, a change should be made in the latter, and all strain upon the neck of the femur, as in standing, avoided. The progress of the deformity may thus be arrested. It is also useful to take the weight of the body as much as possible off the affected limb in walking, the

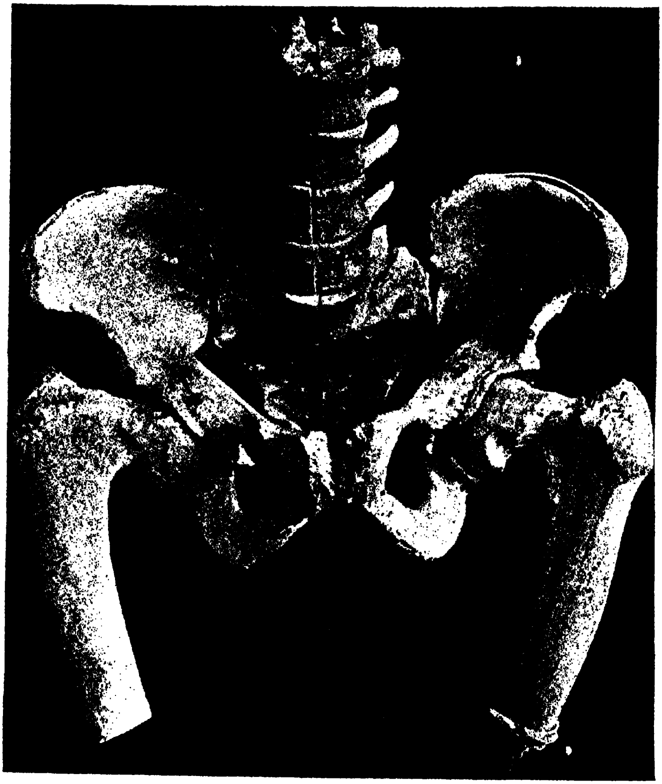


FIG. 451.—Bilateral Coxa Vara due to Osteomalacia (after Albert).

Thomas's caliper splint, with a perineal crutch, being a simple means of effecting this purpose. At the same time massage of the muscles and joints should be thorough. If pain and spasm are present, rest in bed, with weight-extension to the affected limb, must be adopted, and some have attempted to utilise traction force in this way to produce lengthening of the limb. It is certain that some of the disability is removed by stretching the shortened muscles. And in

two cases under the author's care it was clear that an opening out of the angle of inclination had occurred. In one case the leg gained half an inch in length and in another three-eighths of an inch, although the treatment was prolonged for months.

Tenotomy of the adductors offers a certain amount of functional improvement. We should recognise, however, that if the shaft of the femur is abducted by this procedure, the femoral head is still further displaced downward in its relation to the acetabulum. For the same reason forcible redressment can be of little use.

We are therefore driven to attack the bone itself, but we must remember that in unilateral coxa vara we are dealing with a disability only, and that an operation is not free from risk, of which the patient is to be made fully cognisant.

In bilateral coxa vara the condition is much more embarrassing to the patient, and when it is pronounced, the relief to be obtained by operation more than counterbalances the risk.

The operative procedures which have been carried out are resection of the head; cuneiform osteotomy of the neck; osteotomy, simple or cuneiform, of the inter-trochanteric region; and simple osteotomy of the shaft high up. The majority of these operations are open to grave objection. That operation which by general consensus is considered the best consists of removal of a wedge-shaped piece from the femur opposite the trochanter minor. Royal Whitman gives the following description:—

"The base of the wedge, which is situated on the outer side of the bone, should be about three-quarters of an inch in breadth, and its apex should be at the trochanter minor. The upper section of bone should be practically at a right angle with the shaft, the lower being more oblique. The cortical substance on the inner aspect of the bone should not be divided, but reinforced as it is by the cartilaginous trochanter minor should serve as a hinge on which the shaft of the femur is gently forced outwards, until the gap is closed by the apposition of the fragments"[1] (Fig. 452). In almost all cases we prefer to wire the fragments together. The limb is put up in plaster of Paris in extreme abduction until firm union is obtained, the shaft is then brought gradually into the middle line, and the head of the bone thereby raised to its proper position (cf. Fig. 439). Very rarely in extreme cases of mushroom deformity (Fig. 450) resection of the head may be indicated.

Where there is little depression of the head, and the neck of

[1] *Treatise on Orthopedic Surgery*, 2nd edit., 1904.

the femur is merely convex forwards or backwards, cuneiform osteotomy is not indicated. A linear subtrochanteric osteotomy suffices, and the limb can be inverted or everted as may be necessary.

In all cases, before any operation is done, it is advisable to divide the contracted adductors near the pubis by the open method.

FIG. 452.—Outlines showing the Effect of Sub-Trochanteric Osteotomy in overcoming the Adduction of the Limb (Whitman).

Operations on the neck of the femur are undesirable, because of the difficulty of reaching the part and making a satisfactory cuneiform exsection, the increased risk involved in opening the joint,[1] and the possibility of necrosis of the head.[2] There is also the possibility of further shortening resulting after the operation from slipping up of the femur at the site of operation. The great argument against this form of operation is that the same result can be obtained more easily and with less risk by Whitman's operation.

After the operation upon the shaft is completed, the limb is fixed in the position of full normal abduction, either in a plaster of Paris spica bandage, which should include the foot as well; or a long Liston's splint may be used, which has a hinge opposite the hip-joint to permit full abduction of the femur to be made. This is used until the wound is satisfactorily healed, and is then replaced by a plaster of Paris spica. In either case the patient remains in bed for eight weeks or more until firm union has taken place. The abducted limb is now brought parallel to its fellow, and in doing so the head and neck of the femur are elevated to their normal position. The patient is afterwards allowed to walk about in a short spica bandage for a month or six weeks, and finally this is removed.

COXA VARA FROM RICKETS AND OTHER CAUSES

Coxa vara, due to rickets, is less common than we might anticipate. It is as a rule not very severe,[3] owing to the shortness of the neck of the femur at the age when rickets is florid. We

[1] Joachimstal cites two cases in which death followed from sepsis.

[2] Hofmeister and Nasse have been compelled to undertake secondary resection of the head for this cause.

[3] The angle of the neck of the femur usually being from 100° to 110°.

PLATE XXV

Skiagram of a severe Case of Bilateral Coxa Vara of Rickety Origin.

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might imagine that in severe cases of genu valgum, where the lower end of the femur is much adducted, coxa vara must necessarily be present, but this is not the case. A good many instances, however, apart from genu valgum, have been recorded, commencing with the observations of Fiorani, already mentioned (p. 578).

A spurious kind of coxa vara is sometimes met with in rickets, where much bending of the shaft of the femur below the trochanter occurs. This variety is now of historical interest, for it was in a case somewhat of this description that Keetley first initiated what is now recognised as the best form of operative treatment for coxa vara, namely, removal of a wedge from the shaft in the subtrochanteric area.

The symptoms are those already described in essential coxa vara, but for correct diagnosis skiagraphy is essential. Outward curvature of the shaft is sometimes compensated by a downward direction of the neck.[1] Arguing from what occurs in rachitic curves elsewhere we may anticipate a spontaneous return to the normal form in a large number of cases, and fortunately this is so. In a case in Hoffa's private Clinic,[2] the angles in a boy of three were respectively 105° and 110°. Three years later, with general treatment for rickets, they had increased to 120° and 125°.

Spontaneous improvement, however, does not always occur, and, on account of the mechanical disadvantage existing, the condition may run on to a severe and even an acute angled coxa vara, as occurred in a case of Joachimstal.[3] When the patient was six years of age the angle of inclination was about 90°, and at eleven years of age both sides presented an acute angle.

It is evident, then, that in rickets static effects come into play, and they are aggravated by the preceding softening of the femoral neck. It is therefore difficult to assign the exact position in classification of this form of coxa vara. It is included for convenience in the section dealing with static developments. The actual form seen is that described on p. 576, as the trochanteric, the cervical being less frequently met with. Hoffa pointed out that the diagnostic sign of the rickety in contradistinction to the

[1] Cf. "Remarks on Coxa Vara." Drehmann (*Zeitschr. f. orthop. Chir.*, 1906, p. 138) gives a tracing from a skiagram, in which coxa vara on one side is accompanied by coxa valga on the other, both conditions being compensatory to changes in the diaphyses.

[2] Recorded by Carl Helbing, *Zeitschr. f. orthop. Chir.* Bd. xv. 2. bis 4. Hefte, p. 535.

[3] *Handb. d. orthop. Chir.* 6. u. 7. Lieferungen, p. 407.

congenital form is the direction of the epiphysial line. In the former it is oblique, in the latter it is nearly vertical.

As to treatment we have remarked that rickety coxa vara is seldom extreme, and is often compensatory. Other osseous deformities, such as curved tibiæ or genu valgum, are present, and make more imperative demands on treatment. It may be wise, then, to treat rickets generally, and the curvatures of the long bones of the limb locally, and to expect a simultaneous cure of the coxa vara. If it does not take place, the deformity can be rectified on the lines laid down in the discussion on essential coxa vara.

In early infancy, individual cases of true rachitic coxa vara are seen, and may be advantageously treated by fixation in abduction without operation.

Coxa vara due to osteomyelitis, senile osteoporosis, and osteomalacia, which diminish the resistance of the long bones, is met with.

It is remarkable that so few cases have been recorded in osteomalacia (Fig. 454). This is probably due to the difficulty of handling such cases, and owing to their more frequently coming under the notice of the obstetrician. When the softening process has terminated and recovery from the general condition takes place, treatment for coxa vara may be called for.

Space does not permit us to deal here with these rarer forms of coxa vara, and the reader is referred to the original article by Hofmeister.[1]

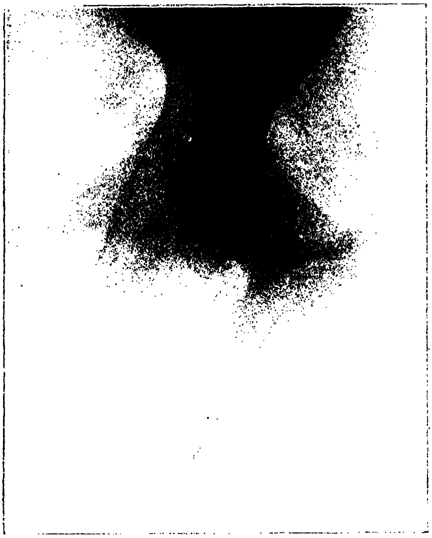
Tuberculosis causes coxa vara in two ways: either a focus may form in the neck of the femur, and so weaken it that bending or even fracture occurs; or, as Kirmisson suggests,[2] the widely-spreading fatty degeneration met with in tuberculous bones, apart from any actual focus in the neck, may be a cause of inclination of the neck.

Simple and malignant cysts of that portion of the bone may produce similar effects.

Arthritis Deformans.—It is probably more correct to say that arthritis deformans about the hip-joint sometimes sets up changes closely simulating coxa vara, than to assert that it is a cause of true coxa vara. The mushroom-shaped head of arthritis deformans is well known, and if this is modified by the wearing away of the upper portion of the head, whilst the lipping below is exaggerated, a condition like coxa vara may be met with. Freiberg[3] has recently

[1] *Beiträge z. klin. Chir.* xiii. p. 1. [2] *Difformités acquises*, pp. 390 and 391.
[3] *Amer. Jour. of Orthop. Surg.* July 1905.

PLATE XXVIII.



Traumatic Coxa Vara, from Separation of the Epiphysis of the neck of the femur.

To face p.

called attention to these cases; but as in his two examples the angles of the neck were respectively 128° and 135°, it is difficult to see why they are called coxa vara. The practical point is that advanced osteo-arthritic changes of the hip-joint may be met with in quite young people; and that, however much clinically a case may resemble true coxa vara, the operative treatment on the lines laid down for the latter is best avoided.[1]

Traumatic Coxa Vara

The researches of Royal Whitman and others during the last ten years, especially since the introduction of skiagraphy, have placed this question in an entirely new light. It is evident that any injury about the neck of the femur, which immediately causes or leads to depression of that part, will ultimately, with or without rotation, give rise to the symptoms of coxa vara. We have therefore to discuss the effects of the following conditions:—

1. Separation of the epiphysial neck in children and adolescents, either partial or complete (Plate XXVIII.).
2. Fracture of the neck of the femur in children and adolescents, either of the "green stick" variety, or complete, or even impacted.
3. Fracture of the neck of the femur in adults.

We have also to consider this important point, that coxa vara of the essential variety itself predisposes to fracture by placing the neck at a disadvantage for bearing strains. And the aggravation of the symptoms following a more or less severe injury may be, as it were, a mere incident in the course of an essential coxa vara. Careful inquiry into the condition of the part before the accident will probably elicit evidence of pre-existing coxa vara, in which case the diagnosis must be "fracture of the neck in the course of coxa vara," and not coxa vara from fracture of the neck. Traumatic coxa vara is not always due to a mal-united fracture, but is often a deformity gradually developed and following on injury. Hoffa therefore divides traumatic coxa vara into two groups: (1) where the lesion takes place from injury in healthy children, and (2) where the fracture occurs in a femoral neck which has become soft

[1] Cf. the bad result in a case of Nasse's, in which cuneiform osteotomy of the neck was performed in a girl of fourteen (Kirmisson, *Difformités acquises*, p. 393, and Nasse, *Beitr. z. Centralbl. f. Chir.*, 1897, No. xxviii.). Some references to coxa vara and arthritis deformans are: Maydl, *Wiener klin. Rundschau*, 1897, Nos. x., xi., and xv.; von Brunn, "Über die juvenile Osteo-arthritis Deformans des Hüftsgelenkes," *Beitr. z. klin. Chir.* Bd. xl. Heft 3; Kirmisson, *Rev. d'orthop.*, Nov. 1898.

owing to some morbid process; that is to say, the typical symptoms of coxa vara are increased by the injury.

The importance of the part played by skiagraphy in the differentiation of these forms of injury is now being fully appreciated. When the present writer discussed eighteen years ago in the *Guy's Hospital Reports* and *Annals of Surgery*, "Traumatic Separation of the Epiphyses," he was able to discover only one undoubted case of separation at the epiphysial line of the neck of the femur. Also in Treves' *System of Surgery*, 1895, it is stated "that there is only one known case in which separation of the epiphysis of the head was shown, on post-mortem examination, to have occurred."

Separation of the Epiphysis in Childhood.—Whilst Whitman holds that fracture is more common at this age than epiphysial separation, yet other writers, especially Hoffa and Sprengel,[1] contend that fracture is rare, and the bulk of cases are due to epiphysial separation.

Separation of the epiphysis is either partial or complete. The partial form is more likely to occur in adolescents, and consists of a rupture of the periosteum and cortical substance at the junction of the head and neck. As the result, an inflammatory process is set up, and owing to the stress of the upright position, the head of the bone becomes slowly depressed, so that coxa vara is established. Again, this partial separation of the epiphysis may occur in adolescents already suffering from a moderate degree of coxa vara. Cases of partial separation give rise to a moderate degree of disability at the time, which, if untreated, increases.

Complete separation of the epiphysis occurs quite near the head of the bone, and occasions definite loss of function, inasmuch as the epiphysial line is situated within the joint, and quite near to the acetabular margin, so that the articular surface of the head of the femur is frequently involved.[2]

Fracture of the Neck of the Femur in Children and Adolescents.—Whitman, to whose writings on this subject we are largely indebted, has brought this matter into prominence. He states[3] that during the past sixteen years thirty-five cases have come under his observation. The fracture may be partial or "green

[1] *Arch. f. klin. Chir.* Bd. lvi., 1898, p. 805. Also Hesse, in investigating this point, concludes that epiphysial displacement is about three times as frequent as fracture. The cases analysed are forty-two in number, and were aged one to eighteen years.—*Zeitschr. f. orth. Chir.* xv. p. 192.

[2] Whitman, *Med. Rec.*, July 25, 1893; *Annals of Surgery*, June 1897, February 1899, and November 1902.

[3] *Orthopedic Surgery*, 3rd edition, p. 562.

stick," or is complete. We have already intimated above that all authors are not in agreement with his views. Whitman maintains that in childhood the narrow neck is more liable to fracture than the epiphysis is to displacement, as the epiphysial junction is thicker and protected by a strong rim of cartilage. He further states that in those cases where three-quarters of an inch of shortening occurs, if the nature of the injury were epiphysial separation, the consequent irregularity within the joint would cause more serious functional derangement than is usually present, and A. Broca[1] appears to support Whitman.

In a case of Whitman's, in a boy aged sixteen, three weeks after the injury there was an inch of shortening with corresponding elevation of the trochanter, and motion was much restricted in all directions. A Röntgen picture denoted partial epiphysial separation. The later history of this case differs from that of fracture of the neck of the femur, in that movement of the joint has remained restricted, as it was at the first examination.

Previously to the discovery of X-rays, fracture of the neck of the femur was known to occur in childhood, but it was regarded by authorities[2] as very rare.

Fracture of the Neck of the Femur in Adult Life.—Pathological and clinical observations have made us well acquainted with the nature of the injury in these cases. It is intra-capsular or extra-capsular, and may be impacted or non-impacted.

We have now to consider the relationship of pre-existing coxa vara to traumatism. In the fully developed case of traumatic coxa vara there is nothing clinically to differentiate it from the essential form. Indeed it appears that with fuller research the number of the adolescent or essential form has decreased, whilst the traumatic variety has increased.[3] In fact, Borchard of Posen[4] attributed essential coxa vara to a series of traumatisms setting up fissures in the bone, resulting in softening and sinking of the neck. But one point militates strongly against traumatism, used in its ordinary sense, being the cause of the majority of cases of coxa vara, and that is the existence of the affection in a bilateral form. We must, however, accept the fact that a hip, the subject of varoid deformity,

[1] *Presse méd.*, March 4, 1905.

[2] Malgaigne, Holmes, Tillaux, Duplay, Réclus, and Hamilton.

[3] Whitman, in seventy-three cases of depression of the neck of the femur, classified twenty-one as traumatic, and most authors agree that coxa vara may be of traumatic origin more often than has been thought, and all cite observations in favour of such a contention.

[4] Second German Congress of Orthopædic Surgeons.

is more liable to suffer from the effects of injury, either on account of the changes in form and the consequent limitation in movement, or because the very processes, which have induced coxa vara, have left the neck weakened.

The practical deduction is this, that in all cases a careful, early, and exhaustive examination should be made and skiagraphic pictures taken *in all positions of the joint*, a minute note of such positions being kept. The history should be carefully inquired into, so that the correct ætiology is ascertained and a sound diagnosis arrived at.

Symptoms of Traumatic Coxa Vara.—In traumatic separation of the epiphysis of the head of the femur, whether partial or complete, the exact diagnosis can only be verified by an X-ray picture, at an operation, or on post-mortem examination. Usually, after a slight injury the patient complains of sudden disability and pain. He limps somewhat, and further shows the typical signs of depression of the neck of the femur. There is some shortening, and this increases if the patient is allowed to walk about. When the separation is complete, the signs of injury to the neck of the femur are well marked, but if it is partial the signs are obscure, more particularly if the traumatism is slight.

Fractures of the neck of the femur in childhood and adult life differ very markedly in their signs.

In children and adolescents the immediate effects of the injury are slight, particularly in the "green stick" variety, so much so that the patient may be able to walk about immediately after the accident, or within a few days.[1] When the fracture is complete a shortening of half an inch to one inch is present. There is elevation of the trochanter, and the movement of the joint is restricted and painful, and the limitation is chiefly in the direction of flexion, abduction, and internal rotation. Whilst the immediate effects of the injury are comparatively slight in children and adolescents, yet as years pass on they often increase and the shortening becomes more marked.

Of the symptoms of fracture of the neck of the femur in adult life it is not necessary to speak at length here.

Diagnosis.—The usual error is that the condition is either put

[1] Thus in a case of Kirmisson's (Gaudier, *Rev. d'orth.*, March 1905, p. 127), a child fell and fractured the right radius. He walked to the hospital and mounted to the first floor to be dressed. A month later he returned to the hospital, and was examined by Kirmisson, who recognised that a fracture of the neck of the right femur was also present.

down to traumatic synovitis, or it is thought to be symptomatic of the onset of tubercular coxitis. An X-ray picture will quickly clear up the question, and the more or less sudden elevation of the trochanter, the rapid onset of shortening, with the loss of flexion and internal rotation, will place the case in its true light.

Treatment of Traumatic Separation of the Epiphysis.—On account of the slight degree of violence, and because the symptoms are not very marked, the patient is generally treated for a contusion; and after two or three weeks' confinement to bed, perhaps not even

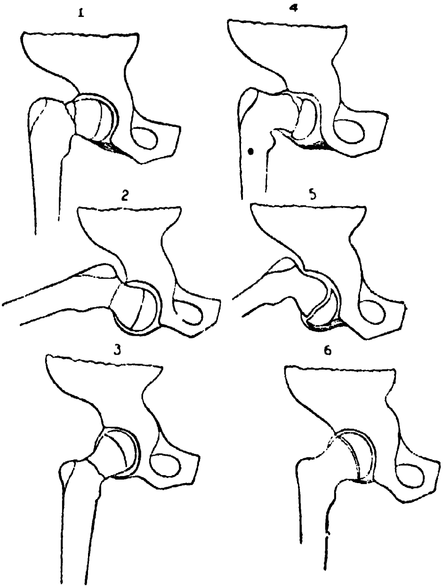


FIG. 453.—Traumatic Coxa Vara; illustrating the Abduction Method of treating the Injury, so as to prevent the Varoid Deformity. 1. Fracture of the neck of the femur. 2. Restoration of the normal angle by forcible abduction. 3. The limb in normal position. 4, 5, and 6 illustrate separation of the epiphysis of the head of the femur treated by the same method (Royal Whitman).

that, is permitted to get about. Then follows the more or less rapid development of the typical signs of coxa vara. Therefore, in dealing with these cases we have to consider: (*a*) The immediate treatment of the diastasis; (*b*) The preventive treatment of coxa vara after the accident; (*c*) The treatment of cases seen two or three weeks after the injury; and (*d*) The treatment of old-standing traumatic cases.

In dealing with traumatic separation of the epiphysis, if it is

not complete, immediate treatment consists of recumbency in bed, with weight-extension to the limb, for about five weeks. Then the patient should be allowed to get up, wearing a caliper knee-splint with a perineal crutch, or the traction hip-splint, thus removing the weight of the body from the injured limb. This should be worn for two or three months.

In dealing with complete separation of the epiphysis, the proper relationships of the head and neck should be restored; and this can best be effected by bringing the limb into full normal abduction

FIG. 454.—The Long Spica as applied for the treatment of Fracture of the Neck of the Femur in the adult, at an Angle of Abduction of 45 degrees (Whitman).

(Fig. 453) under an anæsthetic (Whitman), and fixing it in a plaster of Paris bandage for six weeks. In order to avoid the subsequent depression of the weakened neck when the patient gets about, the caliper or the traction hip-splint should be used for three or four months afterwards. If it is found that the femur is retained more or less in an abnormal position, massage and forcible manipulation are called for. If the case should come under notice when coxa vara is present, then removal of a wedge of bone from the shaft below the line of the trochanters is indicated.

Treatment of Fracture of the Neck of the Femur in Childhood.—In this injury the head of the bone is depressed, and

it is in the position which it would normally occupy on abducting the limb, that is, the head is abducted. Its further abduction is prevented by the tension of the lower portion of the capsular ligament. Forcible abduction of the limb, then, since the head is already held by the capsule in that position, will restore the normal relationship of the fragments; and Whitman says that the appreciation of this fact is the leading detail in practice. The injured limb is abducted under anæsthesia until the top of the great trochanter comes in contact with the acetabular margin. At that moment the line of the neck of the femur is restored. It only remains to place a plaster of Paris spica on the pelvis and the whole length of the limb for three or four weeks, and then to use the short spica of Lorenz, or the apparatus indicated above for the after treatment of separation of the epiphysis.

In dealing with the preventive treatment of coxa vara, the method above described is undoubtedly the best. But we must consider the question of prophylaxis under other conditions, such as in cases of obscure injury about the hip-joint in which no definite diagnosis can be made, and there is considerable suspicion of injury to the neck. In these cases the safe plan is to keep the patient recumbent, with the leg in the abducted position until three or four weeks have elapsed, and then allow the patient to go about with the weight of the body taken off the limb. It is of great importance that the possible development of coxa vara should be anticipated.

When a case is seen for the first time two or three weeks after the injury, where no special treatment has been conducted, and it presents signs of commencing traumatic coxa vara, it is advisable to anæsthetise the patient and forcibly abduct the limb. Such force must be guardedly applied, because of the possibility of a dislocation or fracture of the bone elsewhere.

As to the treatment of old-standing traumatic cases, it falls into precisely the same category, and the same palliative measures should be employed as in essential or static coxa vara.

Treatment of Fracture of the Neck of the Femur in Adult Life.—Abduction to the normal limit is advisable. When the fracture is complete the shortening is reduced by traction and counter-traction, and the limb is then slowly abducted to its full extent. Whitman also advises that the surgeon's hand should be placed so as to push the thigh upwards from beneath, and force the two fragments against the anterior part of the capsule. He says that "when the limit of abduction has been reached the capsule

will become tense, thus directing the fragments towards each other, and the trochanter will be apposed to the side of the pelvis, thus preventing upward displacement. The tension of the muscles, which favours deformity, will be completely relaxed."

Some Earlier References to Traumatic Coxa Vara

1897. WHITMAN. Annals of Surgery. Further Observations on Fracture of the Neck of the Femur, etc.
1897. CHARPENTIER. Thèse de doct. Paris, 1897.
1898. DE QUERVAIN. De la Coxa Vara. Sem. méd. No. 6.
1898. SPRENGEL. Über die traumatische Lösung der Kopfepiphyse, etc. Verhandl. d. deutsch. Gesells. f. Chir., 1898.
Arch. f. klin. Chir. Bd. lix.
1898. KIRMISSON. Rev. d'orthop. p. 459.
1898. JOACHIMSTAL. Sammlung klinischer Vorträge, No. 215.
1899. JOACHIMSTAL. Arch. f. klin. Chir. Bd. lx. Über Coxa Vara traumatica infantum.
1899. WHITMAN. New York Med. Jour., January 21, 1899.
1900. WHITMAN. Annals of Surgery.
1900. FROELICH. Rev. d'orthop.
1901. STIEDA. Arch. f. klin. Chir. Heft 3.
1902. WHITMAN. Annals of Surg., November. Transac. of Amer. Orthop. Assoc.
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A Note on the Fallacies involved in the interpretation of Skiagrams, especially in Coxa Vara and Valga

Mr. Vincent Moxey describes a simple experiment. If a stick with a rectangular handle be held so that its shadow is cast upon the wall, it is found that by simply rotating the stick upon its long axis, or lowering and raising it with respect to the light, any and every angle can be produced in the shadow of the handle. That is, varus and valgus appear at will. In a simple case like this, with the conditions fully known and entirely under control, it is difficult to reproduce the true shape in the shadow.

In the case of coxa vara, that skiagram is most nearly correct which gives the longest neck of the femur, *i.e.* the least foreshortened. If coxa valga is in question, then the skiagram which gives the smallest angle is the most accurate one.

CHAPTER X

COXA VALGA

Terminology—Frequency—Ætiology and Causation—Varieties—Pathogenesis—Symptoms and Signs—Diagnosis—Treatment.

WHILE coxa vara has received much attention during the past few years, very little has been directed to the opposite condition, namely, coxa valga,[1] and notices of it are sparsely scattered throughout surgical literature. Royal Whitman, in his last edition, dismisses the subject in six lines, and Bradford and Lovett devote a paragraph to it.

Starting from the conventionally accepted conception of a varus deformity as one in which the segment of the limb distal to the curve is found adducted, we call that form of bending of the neck of the femur coxa vara, in which the head is displaced downwards and the shaft of the femur adducted. Coxa valga is exactly the opposite condition to coxa vara. The head of the femur is displaced upwards, and the shaft is abducted.

The cardinal signs of coxa valga are abduction of the leg associated with external rotation and limitation of adduction. These, taken with other symptoms and signs to be detailed presently, make up the "symptom-complex."

In effect coxa valga is an opening out of the angle made by the head and neck of the femur with the shaft, and it has not received much notice hitherto, owing to the fact of its sometimes being mistaken for early hip-joint disease; and the clinical symptoms to which it gives rise have been hitherto considered to be of slight importance.

Before we proceed to a description of the affection we must first render clear the terminology. Most of this has been gradually evolved in the description of coxa vara,[2] and the same terms and

[1] This description of coxa valga is essentially the same as that read by the author before the Royal Society of Medicine, London, March 1908.

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measurements are applicable to and in use in descriptions of coxa valga.

If we examine the upper part of the normal femur and make our measurements in a frontal plane, drawing one line (AB) through the long axis of the shaft and another line (CD) through the long axis of the head and neck, we have an angle (CEB). This is called (1) the angle of inclination, or the angle of depression, the cervical angle, or angle of the femur. It varies from 125° to 128° in the normal. Anything above 128° represents coxa valga, and anything below 125° represents coxa vara (Fig. 455). Again, taking the normal femur, and drawing a line (GF, Fig. 455) through the base of the head at a point where the cartilaginous covering ceases, we have (2) Alsberg's line. This line in Fig. 455 cuts AB at H. (3) Alsberg's triangle. The triangle made by the lines KH, HE, and EK is Alsberg's triangle (see Fig. 455). (4) Alsberg's angle, or the angle of direction, or the angle of elevation, is the angle formed by Alsberg's line, drawn through the base of the head of the femur, and the line continued up from the diaphysis, indicated by the lines KH and HE in Fig. 455. It is normally about 41° to 44°.

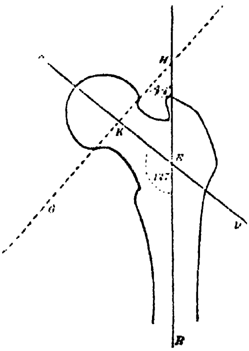


FIG. 455. NORMAL FEMUR.—Angle CEB = Angle of Inclination or Angle of Depression; KHE = Alsberg's Angle of Elevation; Triangle KHE = Alsberg's Triangle.

Inasmuch as in coxa vara there are two elements constantly present, namely, depression of the head and incurvation of the neck of the femur, another term has come into use, namely, the angle of declination (Fig. 457), which is measured in the following way: The femur is stood vertically on the table, and looked at from above downwards. A line (AB) is drawn through the transverse axis of the knee-joint, and a line (CD) is drawn through

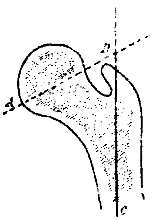


FIG. 456.—AB = Hoffa's Line; CD = Axis of Shaft of Femur.

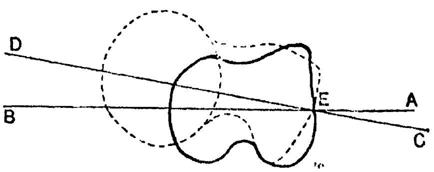
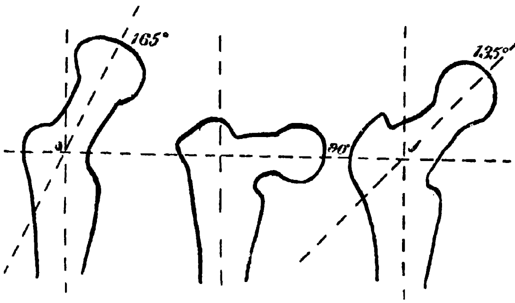


FIG. 457. ANGLE OF DECLINATION.—Femur standing on table, looked at from above down. AB = Transverse Axis of Knee-Joint (or line parallel thereto); CD = Long Axis of Neck; DEB = Angle of Declination = about 12° normally.

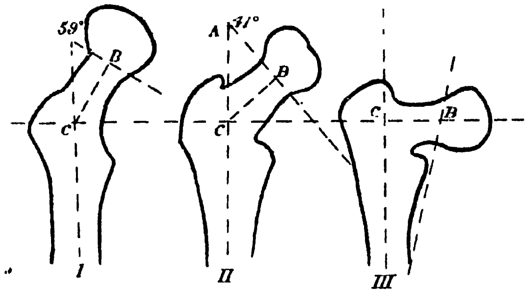
the long axis of the head and neck. The angle DEB is the angle of declination, and is normally 12°. It is increased in some forms of coxa vara and in congenital dislocation. There is reason to suspect that when we know more fully the pathology of coxa valga we shall find not



Coxa Valga. Coxa Vara. Normal.

FIG. 458.—Variations in Angle of Inclination (Young).

only that there is an elevation of the head, but that there is also a distinct curvature forwards or backwards of the neck, and even, as is described in coxa vara, a torsion of it upon itself. Probably the latter condition will be found to preponderate over curvature. It is simpler to



Coxa Valga. Normal. Coxa Vara.

FIG. 159.—Variations in Alsberg's Angle.

deal with one measurement in discussing coxa valga, the angle of inclination, or the angle of depression,[1] or, for brevity, the angle of the femur. In some cases of coxa valga the angle may be increased so

[1] On the whole the term "angle of inclination" is preferable in discussing coxa valga. The expression "angle of depression" is of value in speaking of coxa vara, because the neck and head of the femur are depressed, whereas in coxa valga the contrary is the case, and, therefore, "angle of depression" is apt to be misleading.

much that in X-ray pictures, with the limb everted, the neck of the femur may appear to be in a continuous line with the shaft (see Cases 14 and 16, Figs. 465 and 468).

Relative Frequency.—In order to determine the normal angle of the neck of the femur as well as the relative frequency of coxa valga and coxa vara, measurements were taken by J. K. Young of a large number of specimens in the Museum of the College of Physicians and the Wistar Museum in Philadelphia. They were mostly of adult specimens of all nationalities and both sexes. Measurements were made of the angle of inclination (depression) and the angle of declination. The greatest difficulty was experienced in taking the angle of declination (see Fig. 457), and in some instances it was necessary to have sections of the bones made to determine it accurately. Any angle of depression between 110° and 135° was considered normal, and below 110° as coxa vara by Young, and above 140° coxa valga (Fig. 458). The length of the femora was considered, but is not recorded. The number of femora examined at the College of Physicians was 206, and at the Wistar Museum 615, making a total number of 821. In these there were 8 cases of coxa valga, or 0·97 per cent; 52 of coxa vara, or 6·33 per cent, and the remainder were normal, over 75 per cent of these having an angle of 130°.[1] Of the specimens of coxa valga examined, one was due to tuberculous osteitis, four to arthritis with exostosis, one to rickets, one to hydrocephalus, and in the others the cause could not be determined from the records. The angle varied from 138° to 150°.

The specimen of coxa valga from hydrocephalus, described by Young, is exactly similar to one reported by Humphry in the Cambridge Museum. In that specimen the angle of each neck was 148°; in Young's, 152°. No example of coxa valga from amputation of the femur in early life like those observed by Turner

[1] Of eleven fœtal skeletons examined at the College of Physicians the development was not sufficient to allow of any exact measurements. The head and neck were "ligamentous," and were usually in the axis of the shaft. The measurements of the angles of the infant skeletons showed the usual high angles recorded by other writers.

INFANTS: WISTAR MUSEUM.

Specimen	4204	3 years	Angle of inclination,	135°
,,	4205	1 year	,, ,,	145°
,,	4202	11 months	,, ,,	145°
,,	4203	1 year 44 days	,, ,,	150°
,,	4201	2 weeks	,, ,,	145°

and Humphry was discovered. All the eight specimens of coxa valga examined were unilateral except the one due to hydrocephalus.

Galeazzi, of Milan,[1] describes two cases :—

CASE 10.—A healthy girl, aged 12, without any history of rickets, but poorly fed, had shown signs of difficulty in walking for a period of two years. There was no history of either traumatism, rheumatism, osteomyelitis, or tubercle. She complained of becoming easily tired, and of limitation of movement in the joint, and the left hip-joint was painful. Examination showed a characteristic gait in walking, with marked twisting forwards of the pelvis on the left side, which only disappeared when the patient walked with her left leg externally rotated. In an erect posture, and with her legs parallel, it was noted that the normal lumbar lordosis was increased. The left anterior superior spine was in front of and below the right. She also had slight genu valgum on the left side, and when standing she slightly flexed her left leg, as if it were too long for her. Seen from the front, the left hip appeared flatter than the right one. When the patient stood on her left leg only, a characteristic phenomenon took place. A marked inclination of the pelvis and of the trunk to the left occurred, that is to say, the reverse of Trendelenburg's sign was produced. In dorsal decubitus, and with the legs parallel, the left anterior superior spine was $12\frac{1}{2}$ cm. from the plane of the bed, and the right 11 cm., and this difference became more marked when attempting to correct the outward rotation of the leg. The distance from the left anterior superior spine to the internal malleolus was 2 cm. greater than on the right side. On passive movements abduction was freer than normal, whilst adduction and internal rotation were abolished. The left great trochanter was 2 cm. below Nélaton's line. An X-ray examination showed that the head of the femur was in a right line with the diaphysis, and only one-half of the globular surface of the head, and that the inner and upper half, was in contact with the cotyloid cavity (Fig. 460). The case was treated by an osteotomy to be described presently, and the angle of inclination was diminished from 160° to 130°, and the angle of Alsberg from 67° to 47°.

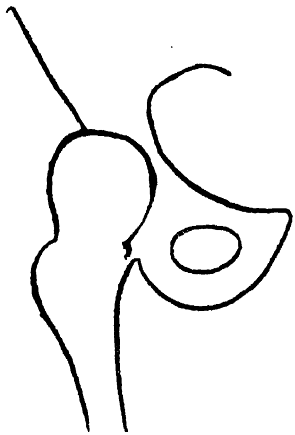


FIG. 460.—Coxa Valga in Galeazzi's Case. Before Operation.

CASE 11.—In Galeazzi's second case, a young girl, aged 13, showing no rickety signs, came under observation. In this patient the gait had been imperfect since she began to walk, though she had only become noticeably lame four or five months previously, and the left hip had been very

[1] *Amer. Journ. Orthop. Surg.*, 1906, iv. p. 244.

painful. In this case there was greater oscillation of the trunk than in the previous one, so that the girl walked with her left leg in abduction, and slightly flexed at the hip, and the trunk was much inclined to the left side. The left leg was 1½ cm. longer than the right, and Nélaton's line was lowered. A certain degree of atrophy in the glutei muscles was noticed, but adduction was the only movement that was limited. An X-ray examination showed an angle of inclination of 169°, and Alsberg's angle measured 94°. The femoral head had lost its roundness, and appeared globular externally (Fig. 461). The higher part of the head was not in the acetabulum, and not more than a quarter of the whole head was in contact with the cotyloid cavity. This explains the unsteady gait and the symptoms of luxation in walking.

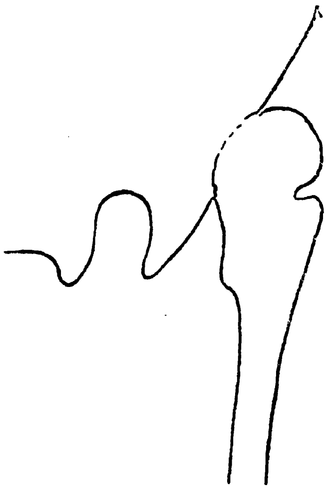


FIG. 461.—Galeazzi's Case of Coxa Valga.

These cases are valuable as they represent careful observations.

CASE 12.—Nathaniel Allison[1] reports the following case of acquired coxa valga:—F. S., male, aged 10, first seen in 1904. Hitherto he had been always healthy. In that year he had injured his right leg by a fall from a fence, and since then has been lame. The limb was tender for some weeks, and very sensitive. After that he walked on this limb without pain, but with it always abducted and externally rotated. When he was examined in August 1904, the right hip was abducted to an angle of 60°, flexed to 20°, and externally rotated to 90°, and all movements were limited to a few degrees. There was spasm of the adductor tendons, and an X-ray plate was taken of the right hip, which showed an abnormal condition of the acetabulum, probably the result of a fracture. Under an anaesthetic, manipulations were carried out, and the hip was bent to 45° and abducted to 20°, but no movements of external or internal rotation were made. The limb was placed in a plaster of Paris spica. After two weeks this was removed, and the walking was painless, but the amount of movement in the hip-joint had not been materially increased by the manipulations. Further treatment was refused for a time, and the boy was taken home.

In August 1906 he returned to the hospital for operation. The degree of abduction was then found to be 30°, flexion 15°, and external rotation 90°. The angle of inclination of the right femur was calculated at 164° and of the left at 125° (Fig. 462). The length of the right limb, taken from the anterior superior spine to the internal malleolus, was

[1] *Amer. Journ. Orthop. Surg.*, January 1907.

1 in. greater than the left, and the right great trochanter was depressed 1 in. below Nélaton's line. It was situated below and behind its normal position, and was difficult to palpate.[1]

When the boy stands or walks, the right leg is abducted and rotated

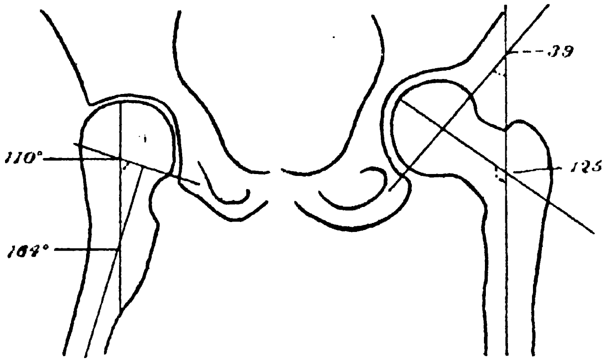


FIG. 462.—Allison's Case of Coxa Valga (right), before Operation.

outwards, which causes secondary scoliosis. He cannot bring the feet together nor alter the position of the limb. Passive movement of the right hip is limited to a few degrees in any direction.

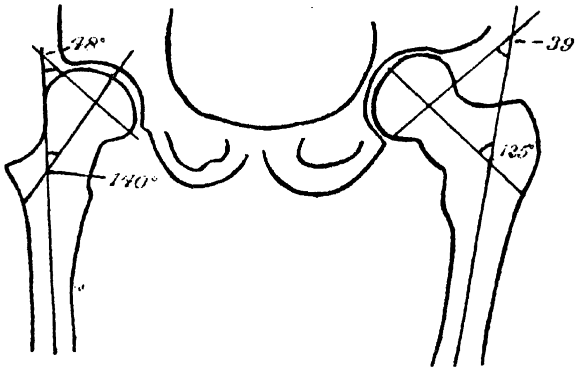


FIG. 463.—Allison's Case of Coxa Valga (right), after Operation.

The diagnosis was made on the symptoms, on the lengthening of the limb, and the fact that this lengthening "can be accounted for by the increase in the angle of inclination of the femur on the right side." "Treatment consisted in a transverse osteotomy of the femur just below

[1] This observation on the situation of the trochanter shows that anteversion of the neck of the femur was present.

the great trochanter. The lower fragment was rotated inwards 10°, and the thigh adducted 10°, whilst the flexion of 15° was reduced and the limb was put in plaster of Paris for six weeks. It was then found that the right limb had become shortened by $\frac{7}{8}$ in., the trochanter had been raised $\frac{3}{4}$ in., and the boy stands with the feet together and with no distortion of the trunk." The angle of inclination was reduced to 140° (see Fig. 463). The anterior superior spines were on a level, and there was no pelvic tilting. Active movement in the hip was not possible, and passive motion was limited to a few degrees. He walks without pain, and the peculiarity of the gait is very much lessened.

Causation.—Putting aside for the present the pathogenesis, we may deal now with the *causes*. So far as the collected cases go, we may classify them as follows:—

A. Congenital

These may be seen either (*a*) in conjunction with congenital dislocation of the hip, or (*b*) not associated with abnormalities elsewhere.

With regard to (*a*) *Association with Congenital Dislocation of the Hip.*—Plate XII., taken from G. A. Carpenter's case, and the author's case (No. 13, Plate XXX., Fig. 2) show this quite clearly, and it is a point of great clinical importance, particularly in the treatment of congenital dislocation. Ætiologically, the question arises whether the coxa valga in these cases is a primary condition of the head of the bone, which has slipped out either before, during, or after birth, because so small a portion of it is embraced by the cotyloid cavity; or, whether the coxa valga is secondary to the dislocation, and is caused by the outward push of the pelvis against the head in walking. This outward push must necessarily cause a stress on the epiphysial line of the neck, and so constantly tend to deflect the head upwards. Whatever may be the order of events, the indisputable fact remains that congenital dislocation and coxa valga are sometimes combined; and this affords an explanation of the extreme difficulty, not only of reducing such a dislocated head, but also of retaining it in the cotyloid cavity. The writer strongly suspects that in those cases of dislocation, where the lower limbs must be put in what is called the axillary position, namely with the knee pointing well upwards towards the corresponding axilla, so as to retain the head of the femur secure, coxa valga is present in a considerable degree. The following cases have come under my notice:—

CASE 13.—*Congenital Dislocation of the Hip and Coxa Valga.*—G. M., aged $2\frac{1}{4}$ years, came to the Royal National Orthopædic Hospital in October 1905. It was noted that she halted on the left hip, and that the left leg was smaller than the right, especially above the knee. As she stands, the body is deviated towards the left side, the left trochanter is prominent, and the head of the femur is displaced upwards. There is no scoliosis. Trendelenburg's sign is present, but this is due to dislocation of the hip, which masks the signs of coxa valga in this respect. The limb is externally rotated; it is not abducted. All the movements of the limb are very free.

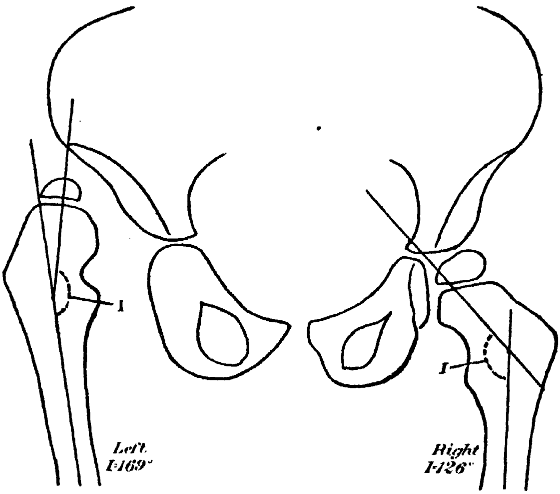


FIG. 464.—Tracing of a Skiagram of Coxa Valga and Congenital Dislocation of the Left Hip in a child, aged $2\frac{1}{4}$ years.

MEASUREMENTS.

	Right.	Left.
Umbilicus to internal malleolus . . .	$17\frac{1}{2}$ in.	$16\frac{1}{2}$ in.
Anterior superior spine to internal malleolus	$16\frac{3}{8}$ in.	$15\frac{3}{8}$ in.
Nélaton's line	Normal.	Left trochanter $1\frac{1}{4}$ in. above.

A skiagram taken with both feet slightly everted shows the dislocation of the left hip, and the angle of inclination on that side to be 169°, and on the right side 126° (Fig. 464).

CASE 14.—*Congenital Dislocation of the Left Hip, with Coxa Valga.*—L. M., aged twelve months, was admitted to the Royal National Orthopædic Hospital on January 21, 1907, for congenital dislocation of the left hip. It is a striking fact that he is the second child of a family

of three, who are all under my care for congenital dislocation of the left hip. The first and third children are females. In this case the left hip was reduced by manipulation and put up in plaster. On October 25, 1907, an X-ray photograph was taken, from which the diagrams are made. The head of the left hip was seen to be in the acetabulum. The angles of inclination were as follows: On the left side 172°, on the right side 164°, taken with the legs lying lax (Fig. 465). The great increase in the angle of inclination on the left side shows that in this patient, and probably in the children of this family, the upper end of the femur is of such a shape as to cause the head of the thigh bone to be

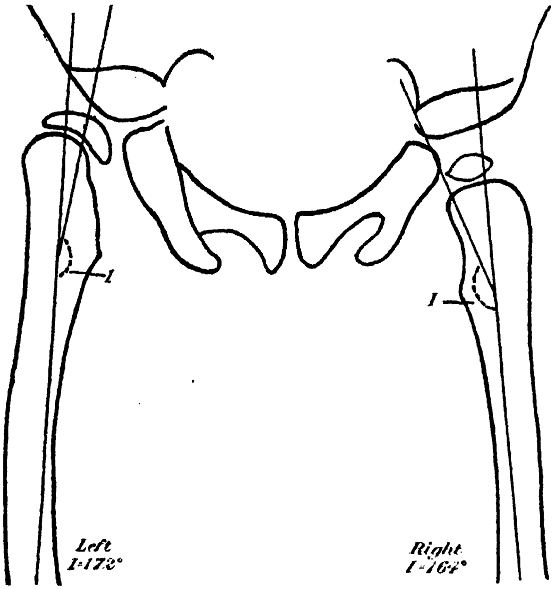


FIG. 465.—Tracing of a Skiagram from a case of Coxa Valga and Congenital Dislocation of the Left Hip in a child aged 12 months.

only partially and insecurely placed in the acetabulum, and therefore liable to slip out under the slightest provocation.

CASE 15.—*Congenital Dislocation of the Left Hip, with Coxa Valga.*—H. S., aged 2, was admitted to the Evelina Hospital under my care on October 29, 1903, with congenital dislocation of the left hip. There was $\frac{1}{4}$ in. shortening on the left side, and the movements of flexion, abduction, and adduction were limited. On December 1, 1903, the Hoffa-Lorenz open operation was performed on the left hip. The capsule of the joint was $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick. This was opened by a crucial incision. At the same time particular care was taken freely to divide the lower part of the capsule and the ilio-psoas tendon. The acetabulum was found to be of good shape and normal. After division

of the above structures, no difficulty was found in placing the head of the bone in the socket so long as the limb was abducted to an angle of 40°.

When seen on December 15, 1904, the legs were equal in length; she could flex the limb to 45°; abduction was excellent, adduction was limited, and extension was full. There was no telescoping of the head of the femur, and it appeared to be in good position and stable; the foot was not everted.

On June 22, 1905, the head of the femur was still in good position

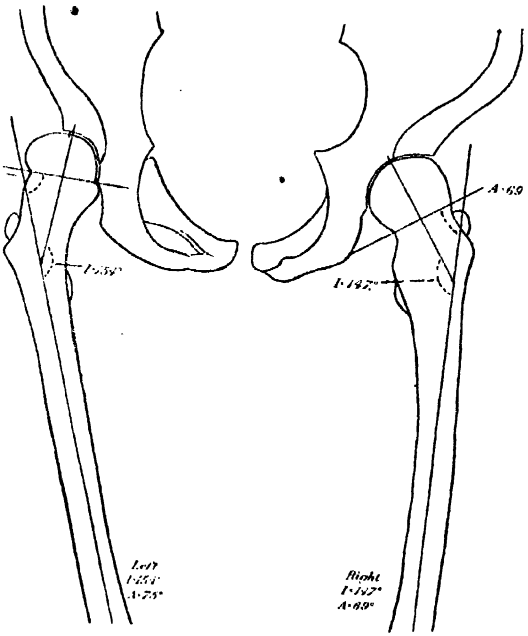


FIG. 466.—Tracing of a Skiagram of a case of Bilateral Congenital Reduced Dislocation of the Hips and Coxa Valga.

and she was walking well. An X-ray photograph was taken on January 26, 1907. The head of the left femur is seen to be thoroughly well placed in the acetabulum, but the upper and posterior part of the rim of that acetabulum is not so well defined as the right, and about a third of the sphere of the head of the femur is not embraced by the cotyloid cavity. The angle of inclination of the left femur is 154° and of the right 147° (Fig. 466).

This case is interesting as it is one of the few successful cases in which I have been able to maintain reduction of the head of the bone after the open operation, and in this case there has been no recurrence of the dislocation for four and a half years.

(*b*) *Coxa Valga, not associated with other Abnormalities.*—Young is responsible for this subdivision of the congenital variety, in which no other abnormalities are present. Whilst it was stated that any increase in the angle of inclination of the femur above 128° constituted coxa valga, yet the angle may be increased to 140° without definite symptoms following. There is, however, one case of coxa valga, published by David, which is assumed to have been congenital, but the evidence is not conclusive. Galeazzi has observed that the normal direction of the epiphysial line of the neck is marked by a line parallel to the aperture of the cotyloid cavity. It is probable, therefore, that careful observations on fœtuses and on the newly born will discover some cases of this type of congenital variety.

FIG. 467.—Right Coxa Valga and Infantile Paralysis, Right Lower Limb (Case 16).

B. ACQUIRED

(1) *Due to Traction exerted by a Pendent Limb.*—It is readily conceivable that the compound effects of continuous traction by the weight of the part, the absence of body-weight above, and the loss of the normal strong contractions of the pelvi-femoral muscles, may lead to coxa valga. Such conditions are more or less met with in all cases of infantile paralysis, and even when inactivity of the limb is very marked. It is possible that coxa valga would be more frequently seen in association with paralytic limbs, which are incapable of weight bearing, were it not for the fact that, owing to the capabilities of modern orthopædic apparatus, paralytic limbs can be made to bear some proportion of the body-weight.

Specimens and cases of coxa valga in infantile paralysis of the lower extremity have been described and recorded by Humphry, Turner, Lauenstein, Albert, and Young; and we are able to give a

description of a case which came under our observation at Westminster Hospital (Fig. 467):—

CASE 16.—*Coxa Valga on the Right Side, associated with Infantile Paralysis.*—P. S., aged 9, came under my care at Westminster Hospital on November 15, 1907, on account of infantile paralysis of the right leg, which had existed since he was 2 years of age. It was seen on examination that there was extreme atrophy of the glutei muscles of the thigh and of the leg. There were no congenital defects, and no history of injury, rickets, or tubercle. The patient was an anæmic and under-fed boy. He cannot walk without support, and when he uses crutches the

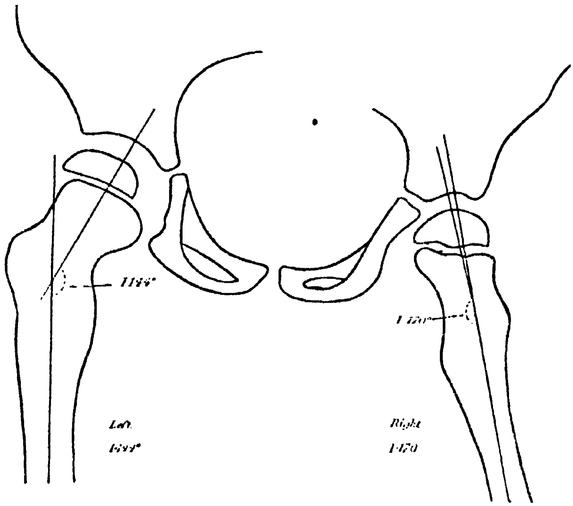


FIG. 168.—Tracing of a Skiagram of a case of Right-Sided Coxa Valga, associated with Infantile Paralysis, from a boy, aged 9 years. The Right Foot was everted when the Skiagram was taken.

right thigh is flexed on the abdomen to an angle of 40°, and the leg is flexed on the thigh at an angle of 30°, whilst the foot is extended and everted, and the back shows a double scoliotic curve, the dorsal deviation being to the left and the lumbar to the right. There is also considerable lordosis. The right side of the pelvis is twisted so that the right anterior superior spine is on a plane lower and posterior to the left. There is also some genu valgum on the right side, and some contraction of the tensor vaginæ femoris and ilio-tibial band is noticeable. The electrical reactions show the reaction of degeneration in all the muscles of the right leg, and the patient has no voluntary power of movement. As he lies in bed, the right limb is flexed at the thigh and knee and falls inwards. Measurements were taken of the limbs:—

	Right.	Left.
Anterior superior spine to knee . . .	$11\frac{5}{8}$ in.	$12\frac{1}{2}$ in.
Knee-joint to external malleolus . . .	$9\frac{1}{2}$ in.	$10\frac{1}{4}$ in.
Great trochanter	$\frac{1}{4}$ in. above Nélaton's line.	Normal.

On passively moving the limbs it was noted that the movements of the right hip were unusually free, except when limited by the contracted ilio-tibial band. The thigh could be fully flexed, and when it was rotated downwards and outwards through a wide area the head of the bone was felt to slip upwards, as if subluxated ("clicking-hip"). After this date (February 3) this sign disappeared, and the patient has been resting in bed with weight-extension on, and a good deal of the tension of the contracted ilio-tibial band has been removed. The right

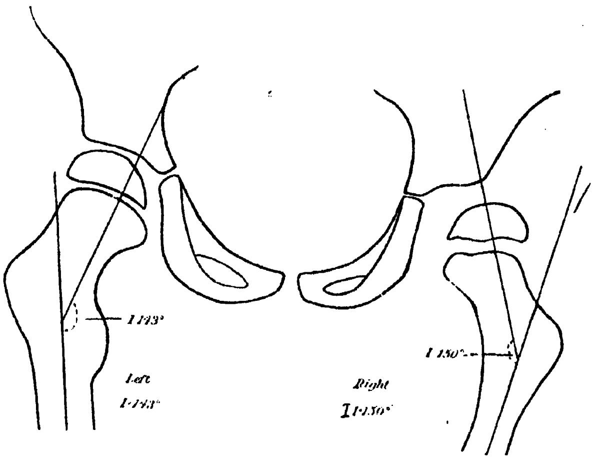


FIG. 469.—The same as in Fig. 468, with the feet placed parallel.

trochanter is about $\frac{1}{2}$ in. posterior to its normal position, and its external aspect is rotated somewhat backwards. Trendelenburg's sign is not obtainable, as the patient cannot stand. X-ray photographs of the limbs were taken in the following positions:—

(*a*) As the patient lay upon the couch, that is with the right foot everted at an angle of about 45°, the angle of inclination on the right side was found to be 170° and on the left 144° (Fig. 468).

(*b*) With both feet placed parallel, the angle of inclination was found to be 150° on the right side and on the left 143° (Fig. 469).

(*c*) With both feet fully everted and the limbs abducted, the angle of inclination on the right side was 204° and on the left 160° (Fig. 470).

(*d*) With both feet fully inverted, the angle of inclination of the right appeared to be 128° and of the left 133°. That is to say, on the right side, between the fully inverted and the fully everted positions, there were 76° of difference, and on the left 27° of difference. This

shows not only the possibilities of fallacy in examining these cases unless X-ray photographs are taken in all positions,[1] but also the extraordinary elevation and twisting of the neck which must have taken place in the right femur to allow of this rotation through such a wide arc as 76°

With regard to the treatment, section of the contracted band of fascia was done, and the boy supplied with an orthopaedic apparatus, taking its bearing from the ischial tuberosity, and made rigid from the hip downwards. It was useless to attempt any other treatment for this limb except persistent massage and galvanism. If recovery of any of the muscles takes place, the possibility of tendon grafting and arthrodesis may be considered.

Coxa valga also occurs after amputation through the thigh in early childhood, as we have mentioned above.

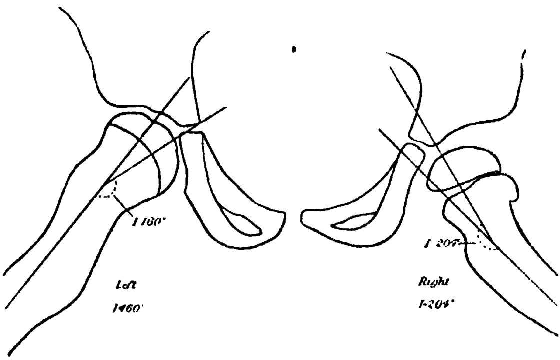


FIG. 470.—The same as in Fig. 468, with the feet fully everted and the limbs abducted.

(2) *Static or Functional Varieties.*—Wolff's law shows that the shape of the bones is determined by conditions of reaction to the body-weight and the stress and strain of muscular action. A femur performing its functions in an adducted position will eventually assume a different shape from one which works in an abducted position, so that from tilting of the pelvis differences in the shape of the thigh bones are to be anticipated. When the centre of gravity of the trunk is disturbed, as in scoliosis, the femora will be subjected to different conditions of stress and strain due to unequal loading, which is just as much a static condition as over- or unloading. Certain facts show that considerations of this nature must be taken into account in seeking to explain some cases of coxa valga.

In hip-joint disease, where the limb has been abducted, Galeazzi says that a degree of coxa valga has been induced. Unequal loading

[1] See Note, p. 602.

perhaps explains the coxa valga in the scoliosis case of Mauclaire and in the genu valgum case of Gangolphe. It is highly probable that static conditions govern the association of coxa valga and genu valgum noted by other writers. Thus genu valgum on one side is associated with coxa vara on the same side and coxa valga on the other. In Galeazzi's case, in which the patient always leaned on a paralytic limb in walking, the pelvis became tilted downwards on that side, so that the limb was in an abducted position, and coxa valga resulted. If, in this case the femoral neck had been deficient in resistance or incapable of reacting to the stimulus of this increased strain, it is probable that it would have collapsed and coxa vara resulted.

A case of what may be termed compensatory coxa valga from fracture of the shaft of the femur, also came under my notice at the Royal National Orthopædic Hospital. The description of it is as follows :—

CASE 17.—*Right Coxa Valga, following Fracture and Mal-Union of the Shaft of the Femur.*—G. M., aged 8 years, came under my observation at the Royal National Orthopædic Hospital on July 18, 1907, on account of lameness of the right leg. In October 1906 he was run over by a motor-car and was taken to a Union Infirmary. The right thigh was considerably crushed, and he remained in the infirmary until Christmas. The parents said that when he left the infirmary there was no support placed on the leg. On account of the lameness he went again to the infirmary at Easter 1908. He was placed in bed for a time, and then went to a convalescent home. On examination the child is a pale, under-sized boy, and stands with the right leg bowed out, and there is an extensive curve outwards occupying the greater part of the right femur. The right trochanter has lost its natural prominence, and in this situation there is a marked depression. The external surface of the trochanter looks backwards. There is no scoliosis. Trendelenburg's sign is absent. When he walks, the chief sign is limping, but he has no pain. The limb itself is rotated outwardly, but abduction is not marked. When he lies down, flexion at the right hip is normal. Abduction can be carried out to an angle of 45°, adduction is limited to 20°, external rotation to 30°, and internal rotation is free only when the thigh is flexed.

MEASUREMENTS.

	Right.	Left.
Umbilicus to internal malleolus	27 in.	27½ in.
Anterior superior spine to internal malleolus .	24 in.	25 in.
Nélaton's line	Right trochanter normal.	Left trochanter ½ in. above.

An X-ray photograph was taken of the right leg with the foot

PLATE XXIX.

FIG. 1.

Skiagram of patient (Fig. 472), showing the co-existence of Coxa Valga and Genu Valgum.

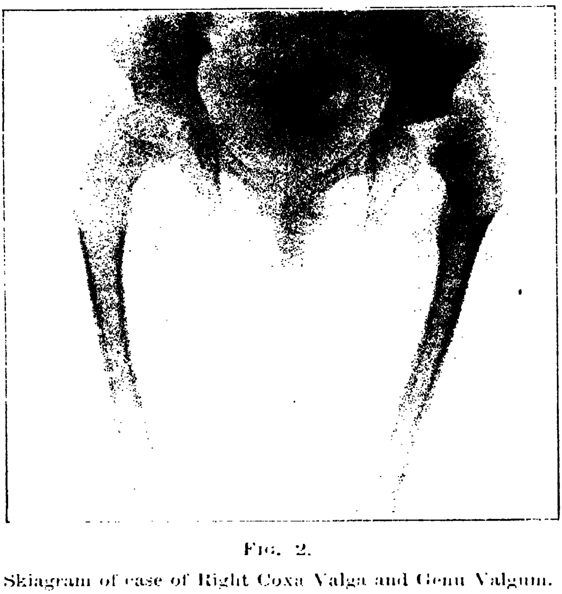


FIG. 2.

Skiagram of case of Right Coxa Valga and Genu Valgum.

To face page 61

to the front, and the angle of inclination was found to be 152° (Fig. 471).

With regard to the treatment the obvious thing to be done is to remedy the mal-union of the femur by operation. When the static conditions are altered it is almost certain that at his age the coxa valga will gradually disappear.

The connection between *genu valgum* and *coxa valga* is illus-

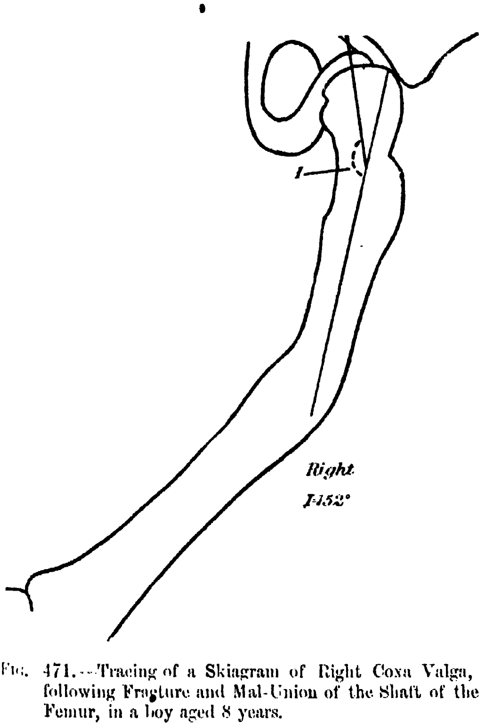


FIG. 471.—Tracing of a Skiagram of Right Coxa Valga, following Fracture and Mal-Union of the Shaft of the Femur, in a boy aged 8 years.

FIG. 472.—Left-sided Coxa Valga and Genu Valgum. See Skiagram, Plate XXIX.

trated by the following case, which came under my notice at Westminster Hospital on December 6, 1907:—

CASE 18.—C. M., aged 11, was admitted for "malformation of both hips." The only point in the history is that there was a difficulty in progression since the child began to walk. There was no history of tubercle, injury, or paralysis, and no congenital defects are noticeable; no history of rickets. The patient is a feeble boy, and stands and walks on a wide base, with feet apart and the knees approximated. Both feet

are flattened and the knees are valgoid. There is slight scoliosis, with the convexity of the lumbar curve to the left. In walking, he rolls about, but does not limp; the pelvis drops to the left side, and there is slight lordosis. It is seen that the right trochanter is not so prominent as the left. The left leg shows external rotation at an angle of 45°, on standing, and the distance between the malleoli, with the knees ⅛ in. apart, is, when he stands, 5½ in., and when he lies down 4½ in. The measurements are as follows:—

	Right.	Left.
Umbilicus to internal malleolus . . .	25⅝ in.	25⅝ in.
Anterior superior spine to internal malleolus	24⅜ in.	23⅞ in.
Trochanter	⅛ in. above Nélaton's line	Normal, but displaced slightly backwards.

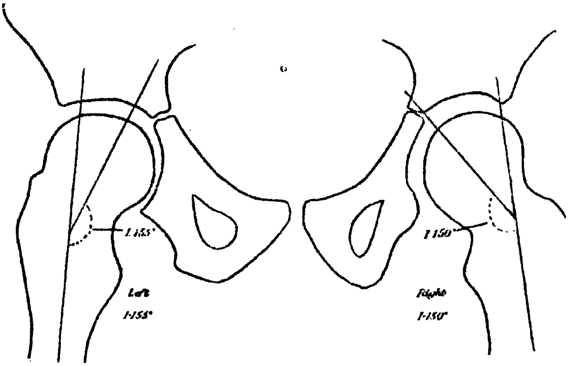


FIG. 473.—Tracing from a Skiagram of a case of Bilateral Coxa Valga associated with Scoliosis and Genu Valgum, taken from a boy aged 11 years. The feet were slightly everted.

Trendelenburg's sign (see footnote, p. 586) is absent on both sides as they are tested alternately.

Passive movements: with the limbs extended, on the right side, abduction is 40°, adduction 20°; left side, abduction is free to the right angle, adduction is limited to 5°. With the thighs and knees flexed: on the right side abduction is very free and adduction is good; on the left side abduction is very good and adduction is limited. On fully flexing both thighs simultaneously, the femora are rotated outwards. It was also noted that the head of the femur on the right side appeared to be unduly movable in the acetabulum.

Skiagrams were taken in three positions: first, with the patient lying as he was accustomed to do, when the angle of inclination on the right side was found to be 150°, on the left side 155° (Fig. 473). The feet were then fully inverted, and the angle on the right side was 130°, on the left 137° (Fig. 474). The limbs were then fully turned out; the angle on the right side was 163°, on the left 170° (Fig. 475).

PLATE XXX.

FIG. 1.

Coxa Valga and Genu Valgum.

PLATE XXX. (*Continued*).

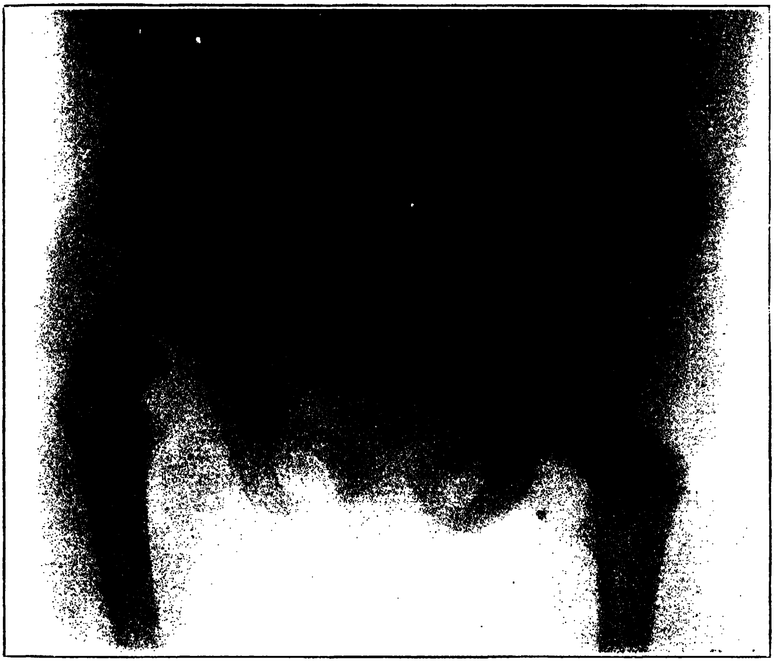


FIG. 2.

Coxa Valga and Congenital Dislocation of the Hip

Page

With reference to the treatment of this case, the right thing appears to be to cure the genu valgum and to note the effect on the angles of inclination.

(3) *Traumatic.*—The deformity arises after fracture of the

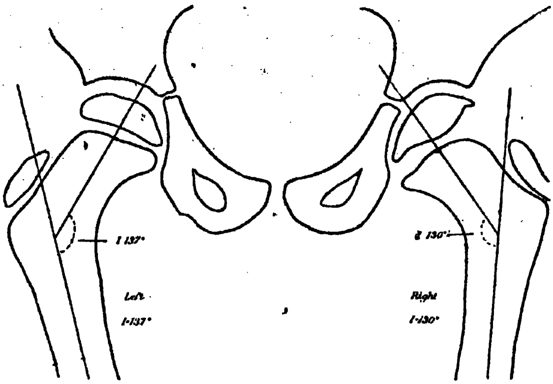


FIG. 474.—The same with the feet fully inverted.

neck of the femur, with impaction and mal-union, and after injuries and separation of the epiphysis. It is rare, but it is quite con-

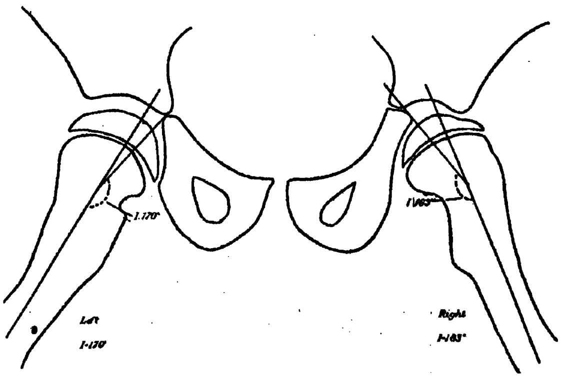


FIG. 475.—The same with the feet fully everted.

ceivable that it can be produced by a direct fall or blow on the great trochanter. Thiem,[1] Hoffa,[2] Kölliker,[3] Manz,[4] J. K. Young,[5]

[1] "Schenkelhalsbruch mit Verlängerung des Beines; Coxa valga traumatica," *Verhandl. d. deutsch. Gesellsch. f. Chir.*, xxvi. Congr. 1897, p. 65.

[2] *Lehrbuch d. Fracturen u. Luxationen*, 1904, p. 410.

[3] *Münch. med. Wochenschr.*, 1905, lii. p. 1718.

[4] *Beitr. z. klin. Chir.*, Tübingen, 1900, xxviii. p. 29.

[5] *Amer. Jour. Orthop. Surg.*, 1907.

and Drehmann[1] have recorded cases. The case quoted by the last-mentioned writer is somewhat striking. A woman, of 46 years, fell on her right hip. Although it was very painful she was able to walk a considerable distance to her home. The leg was abducted and lengthened. In a few days she was about again, using a stick. The movements were considerably interfered with, especially those of adduction and rotation inwards. Later on, the injured limb was found to be $2\frac{1}{2}$ cm. longer than the other, and it was also much abducted; and it was found that the lengthening could not be neutralised by tilting the pelvis upwards on the injured side. A high boot, with a thickening of 3 cm. to the sole and heel, was fitted to the sound side. A skiagram showed the existence of an impacted fracture, coxa valga, and an angle of inclination of the neck of 155°. This case, then, affords one interpretation of a fact noticed in general surgical text-books, that occasionally actual lengthening may result from fractures in the neighbourhood of the hip-joint.

Bradford and Lovett[2] also state that coxa valga has been recorded following a severe fracture of the lower end of the femur and knee-joint.

(4) *Associated with Rickets or other Processes of Bony Softening, such as Osteomyelitis and Tubercle.*—Authors speak of a rachitic form of coxa valga, and undoubtedly some instances are met with in rickets, though primary rickety coxa valga is probably rare, and the affection is more or less a secondary result. It is well known that if the neck of the femur is soft it will bend downward, and coxa vara, not coxa valga, will result. What is actually seen in some cases of rickets is an inward bend of the lower part of the shaft of the femur, as in case No. 18; whilst the femoral head is abnormally in a line with the upper part of the curved shaft, that is, a compensatory coxa valga has developed, neutralising more or less the primary rachitic deformity. Tilanus[3] gives details of and figures a case of compensatory coxa valga occurring in a boy, aged 12, in the course of infantile osteomalacia.

(5) *Idiopathic.*—This term is used because certain cases, not readily falling into the above groups, are met with, and have been considered to be analogous to a form of coxa vara. The latter is really a static condition, and it is very probable that the so-called

[1] *Zeitschr. f. orth. Chir.* Stuttg. 1906, xvi. p. 179.
[2] *Orthopedic Surgery*, 3rd edit., 1905, p. 321.
[3] *Rev. d. orthop.*, March 1, 1907.

idiopathic cases of coxa valga depend upon an anomaly of gait or attitude. Other cases are probably congenital. To the author, at all events, an idiopathic coxa valga does not appear probable, and the existence of this form is by no means clearly substantiated, nor generally accepted. It is possible, however, that cases may be met with, due to some abnormality in the growth of the bones or associated with a wedge-shaped epiphysial cartilage at the neck of the femur, the base of the wedge being downwards. Even if such cases occur, it must be a very fine line which divides such forms from congenital ones. Again, it must not be forgotten that in the fœtus, coxa valga is a normal condition, and may persist after birth.

Pathogenesis.—Much light is thrown upon this point by the remarks on causation, and a few words may be added. The normal shape and position of the head and neck of the femur depend upon the nice adjustment of certain forces, namely, weight pressure, resistance of the bone to this pressure, and muscular tension. If any one of these factors, or all of them, are varied in degree, altered in direction, or destroyed, changes take place conformably with Wolff's law, and the head and neck of the femur assume different positions and directions. To take an example from the better-known deformity, coxa vara, if the resistance of the bone is lessened by rickets, the effects of the superincumbent weight and the pull of muscles come into play, and we find the head of the bone gradually sinking until it is at a right angle or less. Again, if the continuity or the resistance of the neck be suddenly destroyed by separation of the epiphysis or fracture, the pelvi-femoral and pelvi-trochanteric muscles retract to their fullest extent, drawing the shaft of the femur upwards, and coxa vara results. That is to say, in these traumatic cases an alteration in one factor only, namely, the tensile strength of the neck of the femur, results in coxa vara. Now, let us suppose that the weight of the body above or—what comes to the same thing—diminution of pressure from below is brought about, that is, the limb is pendulous. Then the most important factor in determining the normal angle of the neck of the femur is lost; and as it grows, it approximates towards a straight line with the shaft. It must also not be forgotten, in connection with infantile paralysis, that the pull of the powerful psoas muscle, which curves beneath the neck of the femur, and is responsible to some degree for the normal angle of the neck, is either much diminished or entirely destroyed. There is no doubt that the

normal ilio-psoas is a factor of importance in the production of the usual angle, and when the muscular force is lost, the angle tends to increase.

In the treatment of fracture of the neck of the femur, when extension by weights is used, great care should be exercised that the limbs are placed parallel and that the proper amount of weight is employed. If too much weight is used, the shaft will be dragged too far downwards, and the head will unite at a very obtuse angle; coxa valga will be produced. If too little, the opposite condition, coxa vara, will follow. Therefore every case should be examined through the screen from time to time after it has been put up, so as to ascertain that the fracture is in the best possible position.

In congenital dislocation, when the head is displaced upwards, the thrust of the pelvis downwards and outwards in walking, in unilateral cases, must naturally cause the angle of inclination to open out, and the effect of this thrust is increased by the frequently abducted position of the limb. In scoliosis there is no doubt that coxa valga arises on that side to which the pelvis inclines, but further observations are needed by means of the X-rays to ascertain if coxa vara on the opposite side is always associated.

As to the occurrence of coxa valga in rickets, it is difficult to explain why it arises, unless we accept the view that it is compensatory to excessive external curvature of the shaft of the femur. The opposite deformity, coxa vara, is easily explicable and rational, and, as we have already remarked above, rickety coxa valga must be excessively rare. When it occurs secondarily to some other deformity, such as genu valgum, static conditions may afford the necessary clue.

Symptoms and Signs.—The cardinal symptoms are lengthening of the limb, and abduction of one or both lower extremities, associated with external rotation and limitation of adduction.

(1) *Pain and Spasm.*—At the onset of the trouble the patient often experiences fatigue and wandering pains in and about the hip-joints, and sometimes it will be noted that the abductor muscles of the limbs are in spasm.

(2) *Gait.*—In a unilateral case it is limping, and the trunk is inclined towards the affected side. In bilateral cases it is rolling, sailor-like, and unsteady, and is reminiscent of the walk in congenital dislocation. The cause of the unsteadiness and uncertainty is that the head of the femur is not firmly and wholly planted in

the acetabulum. Only the inner and upper portion of the convexity of the sphere lies in the cotyloid cavity. In some cases a partial subluxation occurs in walking; or, when the patient is lying supine and the limb is flexed, abducted and rotated outwards, a distinct slip upwards of the head may be felt.

(3) *Lengthening of the Limb.*—In a unilateral case the limb is lengthened 2 cm. to 3 cm., and tilting upwards of the pelvis does not compensate for the increased length. In fact, it may be necessary, in order to render the limbs parallel, to compensate on the sound side.

(4) The limb is abducted and rotated out, whilst movements of adduction and inward rotation are limited. This is said to be pathognomonic. There is often some slight limitation of flexion.

(5) In bilateral cases the patient stands with difficulty on one leg. In unilateral cases, when the patient stands on the affected limb, the body is inclined towards the affected side. This is well shown in the photographs of Galeazzi's case.[1] Now this posture is just the opposite to that which obtains in Trendelenburg's sign, which is often seen in congenital dislocation of the hip, where the body drops to the opposite side when the patient stands on the affected limb.

(6) Compensatory changes occur in the trunk. In unilateral cases the upper part of the body is inclined towards the affected side, and there is lumbar scoliosis with its convexity towards the affected limb. Sometimes the pelvis is twisted, so that the anterior superior spine on the affected side is below and in front of or behind the opposite one.

(7) The region over the great trochanter is often flattened. This is in great contrast to what is seen in congenital dislocation, where it is unduly prominent. Further, the great trochanter is often below Nélaton's line, and its outer surface is frequently displaced backwards. This displacement backwards points to the probable existence in coxa valga, not only of increase in the angle of inclination of the femur, but also of incurvation, or a forward convexity of the neck, as in coxa vara. There may also exist some torsion of the neck on itself, but no observations exist on this point. The lowering of the great trochanter is not observed if there be a widened acetabulum, or if the case be complicated by congenital dislocation of the hip, or associated with infantile paralysis.

(8) Finally, the last word rests with careful skiagraphy, and we think that all cases described as coxa valga will not bear close

[1] *Amer. Journ. Orthop. Surg.*, 1907, p. 245.

analysis. Skiagraphy requires great care, and the position of the limb must be carefully noted.[1] Thus a case of coxa vara, if rotated out through 90°, will appear as coxa valga, that is to say, the farther we deviate from a plane transecting the femoral neck frontally, the more valgoid will the neck appear. There are, however, two means of avoiding this failure. We should be certain that we see the anterior edge of both trochanters clearly in the skiagram. A more trustworthy method is that which we have adopted of having the X-ray photographs taken in at least three positions of the limbs, namely, both feet fully inverted, both feet straight to the front, and both feet fully everted. If the supposed deformity cannot be made to disappear in any position, then coxa valga is present. A coxa vara may by rotation through 90° be mistaken for valga; but no amount of rotation can make a valga look like a vara. An excellent method is to take the X-ray photographs stereoscopically, and then have a reduction made.

As the cases which came before our notice increased in number, we became aware of the necessity of taking the photographs of the limbs in the positions of eversion, inversion, and with the feet to the front. It is essential that the tube be kept at each exposure in the same position, and the patient's body as well. Not only should the position of the limbs be specified, but the angles of inversion and eversion noted. In the case of young children it is also necessary to give an anaesthetic.

Many of the records in literature, so far as the angles of deviation are concerned, are vitiated by the absence of the above precautions, and it is not improbable that, relying too much on imperfect X-ray work, some cases have been designated coxa valga which are not so.

Diagnosis.—The cardinal and other symptoms have been already dwelt upon, but in the various types of cases some of the signs may be modified. Shortening of the limb, rather than lengthening, exists in congenital dislocation and in infantile paralysis due to general atrophy. Again, the movements of adduction may be very free in paralytic cases. Further, the trochanter is raised, and not lowered, when coxa valga is associated with congenital dislocation, and here, too, the trochanter is also prominent. In some cases the trochanter is displaced backwards, and incurvation of the neck is probably present.

The chief cause of error is confusing an incipient tuberculous

[1] See also Note, p. 602.

coxitis with coxa valga, but this can be readily avoided if we remember that in the latter upward tilting of the pelvis does not compensate for the lengthening of the limb. Again, sacro-iliac disease, on account of the abducted position of the limb and apparent lengthening and dropping of one side of the pelvis, may lead to mistakes.

Treatment.—The subject has hitherto received such scanty notice that no definite lines of treatment have been laid down. Independently the writer treated one case, and he found afterwards that the same plan had been adopted by David, namely, placing the limb as far as possible in the adducted position. The limb was adducted and rotated inwardly under an anæsthetic, and fixed in a plaster of Paris spica. David succeeded in improving the angle of depression in his case by 7°, but we cannot say that our efforts met with success. In some cases equalisation of the limbs by the use of a high sole on the sound side will not only improve the gait, but will lessen the angle of inclination by changing the direction of the weight-pressure.

Wallace Blanchard[1] devised a cuneiform osteotomy of the neck for this condition, but this is not a very easy performance, and the success of the after-treatment is more problematical than in subtrochanteric osteotomy.

Arguing from the analogy of coxa vara, where the deformity is readily remedied by the removal of a wedge of bone, with its base outwards, from the subtrochanteric region, it ought to be the right thing to remove in a case of coxa valga a wedge of bone, but with its base inwards. This, however, is a troublesome proceeding on account of the immediate neighbourhood of large vessels, particularly of the internal circumflex and superior perforating arteries.

Galeazzi has obtained good results in his cases by performing a linear osteotomy well outside the joint, at the base of the neck, and not through it. He is convinced that in all anomalies of direction of the neck, the part to be operated upon must be this region, and not the subtrochanteric. He further points out that if the section is made at the spot indicated, the pull of the great muscular masses whose tendons are inserted into the great trochanter is such as to drag the shaft of the femur upwards and lessen the angle of inclination. Afterwards he applied sufficient traction to the leg to obviate great displacement of the fragments without preventing the gradual ascent of the trochanter, and he followed step by step,

[1] *Amer. Journ. Orthop. Surg.*, January 1907.

by means of X-ray photographs, this upward movement of the trochanter, which he stopped at the proper moment by means of a firm plaster of Paris spica bandage. The success of his treatment is indicated by figures (Figs. 476 and 477).

In his first case the angle of inclination diminished from 160° to 130°, and the angle of Alsberg from 67° to 47°. In the second case the angle of inclination decreased from 169° to 130°, and the angle of Alsberg from 94° to 40° (Fig. 478), the osteotomy having been completely extra-articular. The hip-joints maintained their

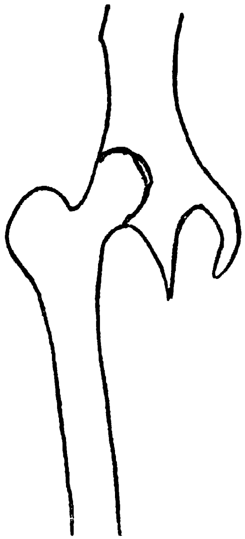


FIG. 476.—Galeazzi's Case No. 10, after operation.

FIG. 477.—Galeazzi's Case No. 11, after operation.

perfect mobility, the gait became normal, and was still unaltered one year after the operations were performed.

Nathaniel Allison divided the bone just below the great trochanter in his case, and remedied the external rotation and abduction, with the result that the angle of inclination was diminished from 164° to 140°. On account of the original injury very little increase of movement of the hip-joint followed.

We have not operated for this condition yet; but, provided that, as in hospital, we can carefully watch the subsequent progress of the case by means of the X-rays, we should give the preference to Galeazzi's method; whereas, under other conditions we are disposed

to think that simple subtrochanteric osteotomy, with adduction of the lower fragment of the femur, will suffice. It will not be necessary to remove a wedge, as the gap left in the bone outside will readily fill up with callus.

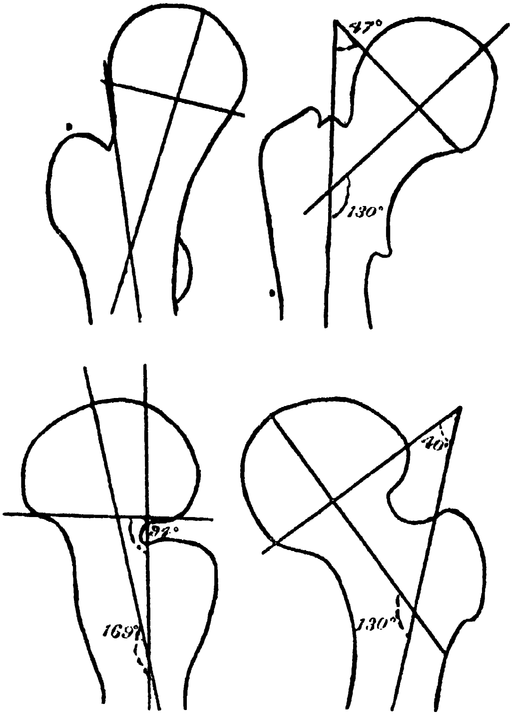


FIG. 478.—To illustrate improvement in Galeazzi's cases.

MUSEUM SPECIMENS OF COXA VALGA AND CASES DESCRIBED IN LITERATURE

Coxa valga was first recognised in museum specimens. The late Sir George Humphry, in 1888,[1] speaks of four specimens in the museum of the University of Cambridge which he examined. The first specimen is seen in the skeleton of a child with hydrocephalus, the angle of inclination of the neck of each thigh bone being 148°, the length of the bones being $9\frac{1}{4}$ in. The second is the upper part of a thigh bone, which was taken from a limb removed at the hip-joint. The patient had

[1] "Observations on the Angle of the Thigh," *Journ. of Anat. and Phys.*, 1888, xxiii.

been paralysed from infancy. In the third specimen the angle of the neck was 150°, and it was judged to have been taken from a paralytic limb. The bone measured 16 in. in length. The last was an amputation stump, in which the angle of the neck was 142°, and it was inferred that the limb had borne no weight for some time previous to the operation.

Albert[1] describes eight specimens: one associated with paralysis of the legs; one with "weakness" of the legs, but no paralysis; one with osteomyelitis of the pelvis; one with rickets; one with osteomalacia; one with multiple exostoses; one with luxation (congenital?) of the other hip; and one with genu valgum.

Turner[2] mentions three specimens: one from an amputation in early life, with an angle of 150°; one associated with tuberculosis of the ankle and knee; and one from fracture of the lower end of the femur with separation of the epiphysis.

Lauenstein[3] notes three specimens, with angles of 140°, 146°, and 155°; and he observed increase in the angle of inclination after amputation through the thigh.

The cases found in literature are the following:—

Mauclaire,[4] to whom we owe the term "coxa valga," described the condition as occurring in scoliotics, especially those with a right dorsal convexity. In March 1894 he performed an autopsy of such a case, and the neck of the left femur showed an angle of declination of 110°, or an angle of inclination of 175°. During life, internal rotation of the limb was impossible and adduction was greatly limited.

Hofmeister[5] observed the condition in a rickety case.

Thiem[6] found coxa valga following injury of the epiphysis of the neck in a child.

Hoffa[7] records a case of coxa valga after fracture of the neck of the femur.

Reichardt[8] mentions one case occurring in connection with infantile paralysis. The case was a girl, aged 13, who had bilateral club-foot since birth and acute anterior poliomyelitis. The right trochanter was 5 cm. and the left 4 cm. below Nélaton's line.

Lauenstein, Gangolphe, and Hau[9] refer to a man, aged 20, who had septic disease in the right knee, causing genu valgum on the same side, and subsequently septic disease in the left hip, followed by coxa valga in that hip.

Hoffa[10] refers to a case following infantile paralysis.

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1 *Zur Lehre von der sogenannten Coxa vara und valga*, Wien, 1889.

2 "Über Coxa Valga," *Zeitschr. f. orth. Chir.* Stuttg. 1904, xiii. p. 1.

3 *Arch. f. klin. Chir.*, 1890, xl. p. 244.

4 "Coxa valga et scoliotique," *Bull. méd.* Par. 1895, ix. p. 347.

5 "Coxa valga," *Beitr. z. klin. Chir.* Tübingen, 1894, xii. p. 245.

6 *Handb. d. Unfallerkrankungen*, 1898, p. 225.

7 *Loc. cit.*

8 "Klin. Beit., Lehre von der Coxa Valga," *Verhandl. d. deutsch. Gesellsch. f. Chir.*, xxx. Congr. (Berl.), 1901, p. 190.

9 "Sur un cas de coxa valga," *Rev. d'orthop.* Par. 1902, iv.

10 *Loc. cit.*

David[1] speaks of a boy, aged 5, who, early in 1903, was treated for pseudo-hypertrophic muscular palsy; both limbs were markedly abducted, and the trochanters were in Nélaton's line, whilst adduction and inward rotation were diminished.

Young[2] describes five cases of his own.

CASE 19 occurred in a boy, aged 8, after traumatism; and Young surmises that fracture of the neck of the femur occurred five years previously, when the child fell and the mother noticed he "walked crooked." The details given of the case are as follows: The patient stands on the left leg, with the right knee thrown forward and inward, the lumbar spine curved, with the convexity to the right, and the left shoulder depressed. In walking he limps on the right leg. In standing, the creases of the buttocks are inclined to the left, and the abdomen is pendulous and prominent. In the lying position there is slight lordosis, and the pelvis is tilted upward on the right side. The right leg is apparently longer than the left, although the bony measurements are the same. On flexion of the right hip, the thigh is carried outwards and adduction is then limited. In the left hip all the movements are normal. The right leg is adducted upon the pelvis. Flexion of both limbs shows the femur of the right leg to be a little longer than that of the left, and the lordosis is not entirely lost until both thighs are flexed upon the abdomen. Measurements taken from the skiagrams show the angle of inclination (depression) on the right side to be 142°, while on the left it is 132°. Young adds: "I divided the adductors from their pelvic attachments, encased the limb in plaster, and abducted the limb for two weeks."

With regard to this case there is one detail which appears to be entirely contradictory. The statement that the "right leg is adducted upon the pelvis" is at variance with the usual experience in these cases. A limb affected with coxa valga is abducted, and not adducted.

CASE 20.—"*Coxa Valga from Forceps Delivery.*—P. R., a girl, aged 4. At birth, forceps were applied to the breech until traction could be made on the feet. She did not walk until she was 4 years of age. The condition then was that both limbs were stiff. The feet were held in the equinus position and the limbs were poorly developed. The trochanters were posterior to, and 1 cm. below, Nélaton's line. The limbs were held in the adducted[3] position, and could be only slightly separated. Abduction was very limited, with noticeable spasm of adductors. Internal rotation was possible on the left side, but very slightly so on the right. Flexion of the thighs on the pelvis was difficult. The outline of the thighs and hips was abnormal on both sides. The skiagram shows coxa valga on both sides, more marked on the right, and backward displacement of the

[1] "Beitr. z. Frage d. Coxa valga," *Zeitschr. f. orth. Chir.* Stuttg. 1904, xiii. p. 360.

[2] *Univ. of Penn. Med. Bull.*, 1907, xx. p. 274.

[3] As a rule in bilateral cases the limbs are held in the abducted position.—A. H. T.

trochanter, also on the right side. On the right side the angle of inclination (depression) was said to be 174°, and on the left side 164°."

CASE 21.—"*Coxa Valga from Separation of the Epiphysis.*—A. R., a boy, aged 4 years. He fell two years previously and afterwards walked with a limp for one week. He was then examined, and the right leg was found to be shortened 1 in. An X-ray photograph showed a separation of the head and epiphysis of the femur on the right side. The limb was put up in an abducted position and a weight of 5 lb. applied. He was discharged four weeks from the time of injury. On May 6, 1906, he was re-admitted on account of stiffness in the right leg, which was more prominent in the morning on rising. He also limped slightly in walking. In a skiagram, the angle of inclination (depression) on the right side was seen to be 144° and on the left side 133°."

CASE 22.—"*Coxa Valga, from Knee-joint Disease.*—W. R., a boy, aged 2½, sustained a slight traumatism of the left knee and hip in February 1903. Extension was applied for three months, and then plaster of Paris to the knee-joint. In October 1903 an abscess formed, and a superficial sequestrum was removed from the outer condyle of the femur, which contained tubercle bacilli. In January 1904 the biceps tendon began to contract, and it was for this he sought advice. Examination showed ankylosis of the left knee-joint from tuberculous arthritis, complicated by the clinical symptoms of coxa valga.[1] The affected limb was 1½ in. longer. Skiagraphically, coxa valga appeared to exist. On the left side the angle of inclination (depression) was said to be 160°, and on the right side 130°." Young adds: "I divided the biceps tendon and equalised the limbs by a sole on the sound side. The leg became ¼ in. shorter." In what way this occurred is not even mentioned or discussed.

CASE 23.—"*Coxa Valga, from Rickets.*—A boy, aged 4, was seen on April 13, 1906. The mother noticed a peculiarity in the child's walk two months previously, the gait being shuffling, and the right leg being more affected than the left. *On Examination*: Nothing important is to be noted in the general condition, save that the epiphyses are slightly enlarged and the abdomen prominent, but there are no other evidences of rickets.[2] No history of injury. The patient stands, resting the weight on the left leg, with the right foot slightly advanced and the knee flexed. He walks with a decided limp on the right side. In the prone position the right foot is slightly everted, the knee slightly bent, and the thigh slightly abducted. Forced flexion is limited, abduction extreme, and adduction slightly limited. There is no contraction of the tendons about the knee or hip. The right leg is apparently longer than the left. A skiagram shows the neck of the femur in the right leg to be in a position of coxa valga. On the right side the angle of inclination (depression) is 150°, and on the left side 140°."

Unhappily, the descriptions of some of these cases of Dr. J. K.

[1] It is much to be regretted that Dr. Young does not describe these symptoms *in extenso.*

[2] This is very insufficient evidence of rickets.

Young's are lacking in essential details, more particularly so far as the clinical signs are concerned; and for his diagnosis he has, in the writer's opinion, too largely relied upon X-rays. The fallacies in connection with this point have been alluded to (pp. 602, 617).

Description of Specimens

By J. K. Young

No. 1.—"1174-34-4. Angle, 145°. Arthritis and deformity of head."

No. 2.—"1175-34-4. Angle, 142°. Upper third of left femur, caries of head and neck. Head and upper part of neck missing. Adjacent surfaces of bone are rough and show more or less periosteal deposit. In the remains of the neck there is a cavity 1·5 cm. deep, but not showing any sinus. Vertical section shows a healthy shaft and healthy spongy tissue of the trochanter major."

No. 3.—"1168-35-4. Angle, 142°. Arthritis and exostosis of head. There is no malformation except at the junction of the head and neck, which is marked by a thick and prominent overhanging ridge of bone. At the inner side of the head this ridge is prolonged to the pit for the ligamentum teres."

No. 4.—"1171-35-4. Angle, 150°. Arthritis and deformity of head. Exostosis and eburnation."

No. 5.—"1229-34-6. Angle, 150°. Anterior bowing of shaft of bone. Axis taken from upper shaft. Rickets, adult bone, but only 31 cm. in length. Posterior wall thick, anterior wall thin."

No. 6.—"130-17. Angle, 150°. Skeleton of negro child, aged 6. Hydrocephalus; bilateral coxa valga. Circumference of head, 70·5 cm. (27·75 in.). The long bones are thin and delicate, and the entire skeleton light in weight."

No. 7.—"2069. Angle, 145°."

No. 8.—"10,300. Angle, 145°."

"In order to make the examination of the specimens of value, every femur in the collection was accurately measured. In this manner it was found that there were fifty-two specimens of coxa vara. Among the 821 femurs, 21 were found among the 206 specimens in the collection of the College of Physicians, which contains mostly pathological material, and 31 were in the Anatomical Institute. The angles varied from 40° to 109°. There were a large number of specimens of impacted fracture of the neck of the femur, with angles below normal, but these were omitted."

CHAPTER XI

GENU VALGUM OR KNOCK-KNEE

Definition—Varieties—Causation—Occurrence—Morbid Anatomy—Symptoms—Results—Estimation of Deformity—Prognosis—Diagnosis—Treatment.

Synonyms—English, *Knock-Knee, In-Knee*; Latin, *Genu introrsum*; German, *Knickbein, X-Bein, Bäckerbein, Ziegenbein, Kniebährer, Knie-eng*, and *Schimmelbein*; French, *Genou cagneux, Genou en dedans*; Italian, *Ginocchio torto all' indentro.*

Definition.—Genu valgum is a deformity of the lower extremities, in which, when the legs are fully extended on the thighs, an angle, salient internally, exists at the knee-joints.

Varieties.—The two chief varieties are—

1. Rachitic.
2. Static.

The varieties less frequently seen are—

3. Traumatic.
4. Inflammatory or Arthrogenetic.
5. Paralytic.
6. Compensatory.

We shall discuss here fully the rachitic and the static, and we deal at once with the other forms.

Traumatic Genu Valgum arises (*a*) After operations for genu varum, when the correction has been excessive, or if the limb has not been properly safeguarded by apparatus for a sufficient length of time after the operation; (*b*) From lateral bending of the bone, after arthrectomy or excision of the knee; (*c*) From fracture of the lower end of the femur (Fig. 479) or upper end of the tibia, or from separation of the epiphyses at the knee.

Inflammatory Genu Valgum is secondary either to an acute juxta-epiphysitis, or epiphysitis at the lower extremity of the femur, and follows tuberculous disease of the knee-joint.

Paralytic Genu Valgum is met with as a sequel of anterior

poliomyelitis, and is due to relaxation or paralysis of the inner hamstrings.

We may now return to the rachitic and static varieties.

Rachitic Genu Valgum occurs in early childhood, between the first and fourth years of age. Occasionally it may be met with starting in later childhood and adolescence (Fig. 480).

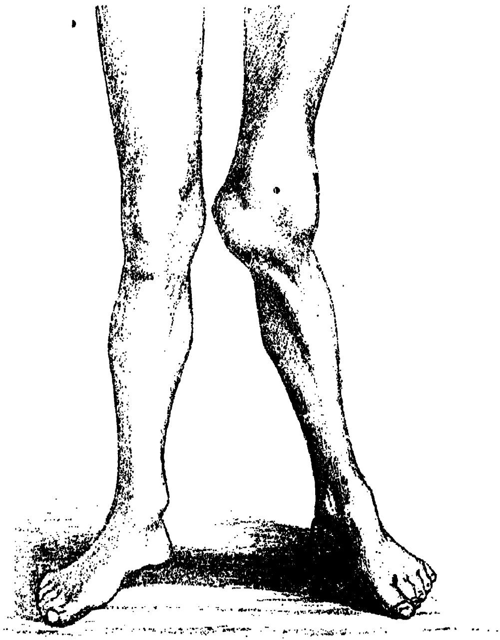

FIG. 479.—Traumatic Genu Valgum, following Fracture of Lower Third of Left Femur, in a boy aged 12 years.

Static Genu Valgum is met with at any age from the time the individual stands erect. It commences usually between the twelfth and eighteenth years, and it is often called *genu valgum adolescentium.*

Causation.—The origin of genu valgum cannot be discussed apart from curvature of the bones of the leg in general. Such curvatures are due, with rare exceptions, either to the effect of the superincumbent body-weight on osseous and ligamentous structures lacking in resistance; or, they arise from the adaptation of structures,

due to the constant repetition of a given position, as in genu valgum adolescentium.[1]

In the erect position the weight of the trunk is transmitted through the articular surfaces of the heads of the femora, knee- and ankle-joints. The knee-joints, with their peri-articular structures, are admirably adapted for weight-bearing, when a vertical line dropped from the head of the femur transects the knee and ankle-joints. Such is the condition of the parts when a normal individual is in the erect position. The knees and feet should be separated by an interval varying with the width of the pelvis. It is sometimes said that a slight amount of knock-knee is the natural condition. This is true in the sense that normally the axes of the femoral shafts converge slightly. In women, the pelvis being wider and the femora shorter, the convergence is more marked than in men. But so long as the knee is not displaced so much inward, that the vertical line above mentioned fails to pass between the condyles, true knock-knee does not exist. However, it is found that on measuring a large number of apparently straight-limbed people the long axis of the femoral shaft does not quite coincide with that of the tibia, but forms an angle of about 15° with it. Or, to put it in another way, an angle of 165° exists

FIG. 480.—Extreme Rickety Deformity and Knock-Knee. Note the peculiar bony outgrowths on the inner side of the upper third of the tibiæ.

[1] Curvatures in the leg bones are seldom due to muscular action, since they are rarely seen in the arms, where muscular action has free play. Also, the curvatures met with are of too diverse a description to be thus explained. If muscular action is the cause of in-knee, it cannot account for out-knee; and there is no doubt that the shortening of the biceps tendon and ilio-tibial band, so constantly met with, is secondary to the knock-knee, and not causal. Again, exaggeration of the normal diaphysial curvatures does not afford an adequate explanation, and when it exists it is purely coincidental. As a matter of fact, in bow-legs, which is the condition most frequently met with, exaggeration and reversal of the normal curves, and *vice versa*, are found in both femur and tibia.

externally, and any lessening of the angle constitutes the pathological condition known as knock-knee.

The lower extremity may be regarded as a jointed rod, which when overweighted may bend into (1) varus, (2) valgus, and (3) valgus, in which the bend is taking place in the joint only.

The problem is, why is it that sometimes genu valgum, but more often genu varum, occurs? In bow-legs the mechanism is simple. Genu varum frequently appears in rickety infants, and they learn to stand and walk with the feet wide apart, so that equilibrium is more stable, with little expenditure of muscular energy. This straddling gait, together with the fact that the pelvis is narrow at this age, and the heads of the thigh bones are near together, throws the vertical lines drawn through the heads of the femora within the knees.

FIG. 481.—Static Genu Valgum.

FIG. 482.—Static Genu Valgum, Diaphysial Type.

The ætiology and mechanism of genu valgum are not quite so straightforward. It is met with as a compensatory condition when the femur is adducted, for example, in *morbus coxæ*, and sometimes in coxa vara.[1] It is

[1] C. B. Keetley, *Orthopædic Surgery*, 1900, pp. 18 and 19.

also seen in growing children with weak muscles and lax ligaments, who stand with the knees close together, apparently for mutual support. In rickety cases, in which there is an unequal curve affecting the shafts of both femur and tibia, it is also observed. In all these instances the mechanism is obvious, deforming movements, valgoid in character, being induced.

But these facts fail to explain how the static or adolescent cases begin, although, if the condition is once started, they help to account for its rapid progress. There is no suggestion that static cases originate in adducted positions of the femur. On the contrary, most surgeons are agreed that the attitude characteristic of commencing *genu valgum adolescentium* is one in which abduction rather than adduction of the thighs is present. It is generally held that the static form of knock-knee is due to adaptive changes arising from the assumption of the attitude of rest. The erect position depends upon muscular action, and its maintenance for any length of time tires the muscles, so that the strain comes upon particular ligaments, namely, the Y-shaped ligaments of Bigelow, the internal lateral ligaments of the knee-joint, and the ligaments of the arch of the foot,[1] all these structures being situated on the inner side of the limb.

Static knock-knee, or the knock-knee of adolescents, is essentially due to muscular weakness. Prolonged standing, fatiguing occupations, and weight-carrying are intensifying causes. It is frequently seen when a youth leaves school and begins to work. Also it commences at this age after an acute illness.

It is not necessary to call up the spectre of late rickets to attempt to explain these cases of genu valgum, as some authors do; for example, MacEwen,[2] Kirmisson, and Keetley.[3]

The Occurrence of Genu Valgum.—Knock-knee is frequently seen, but less often than bow-legs. It abounds in industrial centres, such as South Lancashire, Glasgow, and Lyons, where rickets is common. The infantile form affects both sexes equally; the adolescent form preponderates in males, and is seen in those whose callings require prolonged standing. It is usually double,

[1] In early cases of static genu valgum a distinct space exists in the knee-joint between the internal condyle and the inner tuberosity of the tibia. If the limb is extended, these two parts may, by lateral pressure on the leg, be made to meet with a distinct click, and the deformity is temporarily rectified. Later, when adaptive structural changes in the condyles have taken place, the deformity cannot be reduced. Another point in support of the argument is the frequent coincidence of early genu valgum and flat foot.

[2] *Osteotomy*, 1880.

[3] *Orthopædic Surgery*, p. 14.

but is sometimes unilateral; or knock-knee on one side may accompany genu varum on the other.

Morbid Anatomy.—Several conditions are met with, such as diaphysial curvatures of the femur, tibia, or of both bones. The intra-articular plane may be horizontal or oblique, and the inner condyle relatively enlarged or hypertrophied. The epiphysis of the femur, and to a less degree that of the tibia, together with the epiphysial line, is variously affected. To these changes others must be added, such as varus incurvation of the lower part of the tibia, or a compensatory in-twisting of the foot.

It is misleading, in discussing the conditions in knock-knee, to restrict our attention to the knee and the parts in immediate proximity. The whole length of the lower limbs must be examined in detail.

We may consider, in the first place, specimens in which the diaphysial curves are the most marked features (Fig. 482). This is particularly so in the rickety form. A curvature of the femoral shaft is balanced by one of the tibia, and the appearances in the limbs are so symmetrical that one is tempted to construct a type in which the condition is an exaggeration of the normal curves. But such exaggeration of the normal curves is an accident in rickets, for curvatures of the shafts of the bones, not associated with genu valgum, are as frequently met with. The inclination of the plane of the knee-joint, taken from side to side, varies with the nature and extent of the diaphysial distortion.

To return to the diaphysial curves. That one which is most frequently met with is where the lower third or less of the femur is convex inwards. MacEwen met with it 120 times in 166 affected limbs. These statistics, however, are not borne out by observations made in London. Lateral incurvation may be combined with an anterior bowing, which has no bearing, however, upon the knock-knee.

Less frequently, and then in quite young children, the tibia is markedly affected. In the severe cases there is a sharp bend, with its convexity inwards, situated at the junction of the upper epiphysis with the shaft, while the lower part of the shaft is curved with the convexity outwards.

Another diaphysial condition sometimes met with in genu valgum is an overgrowth of the inner and lower part of the femoral diaphysis. It is as though a wedge had been inserted above the epiphysial line, so that the epiphysis is obliquely placed, and the

inner condyle is abnormally prominent below. This was first described by Mikulicz.

In adolescent genu valgum the chief changes are limited to the lower end of the shaft of the femur and its epiphysis, and such bony changes are adaptive. By actual measurements, radiography, and direct observation of the flexed knee-joint, definite lengthening of the internal condyle can be demonstrated. Reeves[1] mentions that an osseous spiculum is frequently seen near the insertion of the internal lateral ligament in bad rachitic cases (Fig. 480). MacEwen[2] describes fully and discusses these tibial spines, and points out that they do not necessarily correspond with the attachments of ligaments or tendons, but are situated at the points of greatest convexity of the bones.

Microscopically, in the rickety form, the characteristic appearances of the bones are present, but Mikulicz[3] described and figured appearances in adolescent genu valgum, which he considered rachitic. It is remarkable that these appearances were found in the epiphysial line above the internal condyle only, and always gave rise to the same type of deformity; the exact localisation of this bony change in Mickulicz's cases argues, in the author's opinion, strongly against a rachitic origin.

Symptoms.—When knock-knee is present, a space exists between the internal malleoli which may be from two or three inches to eighteen or twenty inches, so that three lines drawn, one through each tibia and one uniting the malleoli, may make an equilateral triangle. The angle made by the axes of the thigh and leg is usually found to be 150° to 160°. Kirmisson states that even 145° is rare, but he has seen the angle as small as 118°. It is a well-known fact that on flexion of the legs in genu valgum the deformity disappears.[4] The reason for this is not clear. The explanation most often advanced is that if the thigh (*ab*) and the tibia (*ac*) are pivoted on an axis (*ad*) (see Fig. 483), the angles (*dab* and *dac*) being equal, on flexion to superposition their axes (*ab* and *ac*) must be parallel. But this explains cases only in which the long axes of the femur and tibia are symmetrically

[1] *Bodily Deformities*, p. 242. [2] *Osteotomy*, pp. 48-49.

[3] Langenbeck's *Arch. f. klin. Chir.* Bd. xxiii. Heft 3, 1878.

[4] Bradford and Lovett (*Orthopedic Surgery*, 3rd edit. p. 287) remark "that if the knee be flexed, while the hip-joint is still extended, the deformity does not entirely disappear, but it is very much diminished." The angle of deformity disappears when the knee is flexed to a right angle, except in those cases where the chief deformity is in the tibia.

disposed with regard to the plane of the articulation between those bones, and this is by no means always the case. Bradford and Lovett[1] suggest that the disappearance on flexion is due to the posterior surface of the condyles being less affected than the under surface. However, the deformity of the condyles is sometimes absent altogether in genu valgum. Other authors[2] suggest that the disappearance of the deformity on flexion is due to the rotation outward of the thigh, combined with relaxation of the ligaments of the knee, and consequent increase of the lateral movements. Morton, of Bristol,[3] says that if care be taken to prevent rotation during flexion the deformity only partially disappears. However, the clinical fact remains that genu valgum is most marked in extension, and all but disappears in flexion. Therefore, in order to cure the deformity, apparatus is of the greatest service when acting on a fully extended limb.

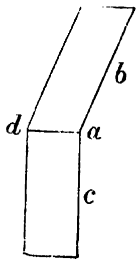

FIG. 483.—To demonstrate the supposed cause of the disappearance of the deformity of Genu Valgum on Flexion of the Knee (Reeves). *b*, Left Femur; *c*, Tibia; *ad*, Line of Knee-joint. If *b* is folded on *c* at *ad*, *b* is exactly superposed on *c*; but see text.

In most cases the deformity is increased when the patient stands. This is due to the relaxed ligaments permitting the lateral movements to become greater under the influence of body-weight. Occasionally, according to Julius Wolff,[4] the deformity can be temporarily removed or lessened by muscular effort. In old-standing cases the ligamentous laxity has disappeared owing to adaptive changes.

The Results.—The results are—

1. The gait is shambling and awkward, partly on account of the weakness of the ligaments, partly because the knees tend to cross, and in some measure on account of the co-existence of flat foot. But, in order to maintain his balance more effectually, the patient inverts the flattened feet and induces a "false varus."

2. Contraction of the biceps tendon, the ilio-tibial band, and external ligaments are secondary results. It is frequently necessary to divide the biceps tendon and ilio-tibial band, even in cases of ligamentous knock-knee, before any reposition can be effected.

3. The tibia is rotated outwards, due partly to the contraction of the biceps acting through the fibula on the leg, and partly to the

[1] Second edit. pp. 647, 648. [2] Gérard, *Rev. d'orth.*, 1897, p. 115.
[3] *B.M.J.*, April 16, 1898.
[4] Quoted by Max David, *Grundriss der orth. Chir.*, 1900, p. 168.

obliquity of the articular surface of the femur. The patella is often subluxated outwards, and in severe cases is dislocated externally.

4. The lateral mobility is often extreme; rotation of the extended leg is often possible through an angle of 45° to 60°. In severe cases hyper-extension of the knee is noticeable on standing.

5. Where the affection is unilateral, or more advanced on one side, obliquity of the pelvis is produced, because one limb is short. If genu varum on one side co-exist with genu valgum on the opposite side, pelvic obliquity is still more marked, and scoliosis is often seen at the same time.

6. Bow-legs are sometimes met with in cases of knock-knee; if the convexity is internal, the deformity is increased, and the difficulty in walking is greater.

From the point of view of treatment we must recognise that cases of knock-knee fall into two distinct classes: those with loose, lax ligaments, in which the bones are often soft; and those where the bones have passed the softened stage, and have become eburnated. For convenience' sake these types are designated as the ligamentous and the osseous. The importance of this distinction will be seen in discussing the treatment.

Method of Estimating the Degree of the Deformity

1. The simplest way is to place the patient in the standing position, taking care that the space which should normally exist between the knees in standing is preserved. In an adult this is one inch, and in a child one-quarter to half-an-inch, and the feet should be so placed that the condyles are not rotated internally. The distance between the malleoli can then be measured.

2. Another method is to sit the patient upon a sheet of white paper, with the toes pointing upward, and trace the outline of the limbs with a pencil. The objection to this plan is that the separation of the malleoli in sitting is no measurement of the deformity in standing, since the laxity of the ligaments at the knee-joint varies much, and it is exactly the standing position which emphasises the extent of the deformity.

3. Mr. Reeves measures the height of a perpendicular drawn from the base to the apex of an obtuse triangle formed by the femur and tibia, and a straight line joining the great trochanter and external malleolus, the perpendicular being taken opposite the knee-joint.

It seems to me that the first plan is least open to objections when properly carried out.

Prognosis.—It is said that in children spontaneous cure takes place, but, with Keetley,[1] we have grave doubts on this point.[2]

In *genu valgum adolescentium* spontaneous cure cannot be expected. And if the cause is not removed a steady increase of the deformity must be anticipated.

Diagnosis.—There can be no difficulty in recognising a case of genu valgum; the chief point is to assign the appropriate cause. Care should be taken not to call the case late rickets unless other signs of that disease are present.

Treatment.—This may be considered under three headings:—(1) General Treatment—Rest and Local Manipulation; (2) Mechanical and Manipulative; (3) Operative.

1. *General Treatment.—Rest and Manipulation.*—If the case is that of a rickety child, diet and hygienic measures should be attended to. A change of air to the country or seaside is of especial value, and the child should as far as possible be kept off its feet when there is marked degree of deformity, but not otherwise. If difficulty arises in doing so, a long outside splint, reaching from the pelvis to four inches below the external malleolus, and with the whole length of the limb, especially the knee, well bandaged to it, is effectual in preventing the child running about.

Manipulations are best carried out as follows:—The splint having been taken off, the limbs douched with tepid water, and the legs fully extended on the thighs, the nurse presses outward the lower end of the femur with the ball of the thumb of one hand, and at the same time presses inward, with the other hand, the upper part of the tibia, thus partially straightening the limb. The pressure is maintained for a few seconds, and then relaxed, the movements being repeated several times. Afterwards the patient's limbs are well rubbed by the nurse. This simple treatment may be carried out night and morning.

In slighter static cases, rest and manipulations, with douching and massage of the limbs, will soon remedy the deformity.

Mechanical Treatment.—This form of treatment is applicable

[1] *Orth. Surg.* p. 20.

[2] The opinions of other authors may be gathered from the following references:—Whitman, *New York Med. Rec.*, July 30, 1877; Gibney, *ibid.* 29th Nov. 1884; Rushton Parker, *Liverpool Med. Chir. Jour.*, Jan. 1887, p. 119; R. W. Parker, *Internat. Clinics*, vol. iv. No. 7; Kamps, *Beiträge z. klin. Chir.* Bd. xiv. Heft 1; Veit, *Arch. f. klin. Chir.* Bd. l. Section 130.

only to the ligamentous varieties, and where the bones are quite soft. It is of no value in children if the bones are hard, nor in adults where the deformity is primarily osseous.

When contraction of the biceps and ilio-tibial band is present, these structures are divided as a preliminary measure. It cannot be denied that good results have been obtained in some extreme cases of genu valgum by mechanical arrangements, which have a rack opposite the knee-joint. The apparatus is put on the outer side of the limb, and is accommodated to the deformity. It is then gradually straightened until the genu valgum is overcome.

The principles upon which mechanical treatment is based are very simple, namely, lateral traction upon the extended knee from a stiff rod or splint, taking its bearings from the great trochanter, the outer side of the thigh, leg, and foot. No interference with walking should be permitted beyond the limitation of movement of the knee, except in very rickety children.

There are various apparatus by which these principles are carried out. The simplest is a pair of long outside wooden or aluminium splints, reaching from the pelvis to the external malleoli. A band of webbing attached to the upper end of the splints, and buckled round the posterior surface of the pelvis, keeps them in position above. Each splint is secured to the outside of the limb by bandages or broad straps of webbing, care being taken to make lateral traction outwards on the knees. In place of bandages or webbing at the knees, a leather knee-cap with buckles may be fixed to the splints.

Bradford and Lovett use a less unwieldy arrangement (Figs. 484, 485) than the above. The apparatus consists of a light steel rod, attached below to a steel sole-plate, and jointed opposite the ankle. It runs up the outside of the leg as far as the trochanter; and there, the rod is bent backward and upward to lie against the upper part of the buttock, and to serve as an arm by which the leg can be rotated if the child turns its toes inward in walking. Its action is regulated by a posterior strap, attached to the tips of the uprights, and an anterior strap, passing across the abdomen, where the uprights begin to bend backward and upward. Riveted to the uprights are two steel semicircular bands, one crossing the posterior aspect of the lower third of the thigh, and the other the upper third of the leg. From the middle of one band to the middle of the other, a strip of steel passes vertically opposite the centre of the back of the knee-joint. The knee is held in position by a knee-cap and straps, the

straps passing around both posterior and external uprights, the knee thus being held extended and drawn outwards.

More complicated and costly arrangements are made; for the majority of cases the simpler forms above mentioned suffice.

When flat foot co-exists, the boots should be fitted with a rubber pad, and the inner edge of the soles and heels should be wedged,

FIG. 484.—Lateral view of single outside Steel Support, with pelvic band and knee-caps, as used by Bradford and Lovett.

FIG. 485.—Antero-posterior view of apparatus, in Fig. 484.

so that they are the eighth of an inch to a quarter of an inch thicker on the inner than the outer edges. In some slight cases of knock-knee this manœuvre will prove sufficient.

In cases where contraction of soft structures on the outside of the joint has taken place it will be necessary to divide them before applying supports. The structures usually requiring division are the biceps and ilio-tibial band. Some surgeons have divided the external lateral ligaments. Operations on the biceps and lateral

ligaments should always be done by the open method on account of the danger to the external popliteal and peroneal nerves.

Wolff's Redressment in Stages.—By ordinary mechanical treatment the correction is very gradual, often occupying months in a moderate case. Wolff[1] has introduced a method by which the limbs can be straightened in weeks rather than months.

The patient is anæsthetised, and manual correction made, moderate force only being used. The limb is straightway put up in plaster of Paris. Two or three days later a wedge, with the base on the inner side of the knee, is cut from the plaster. A further correction takes place, and the bandage is made good again. This is repeated at short intervals, so that in about a fortnight the limb is straight. The patient is then allowed to go about, and later a wedge is cut out from the plaster, with the base at the back, and articulated metal side-splints incorporated, so that direct antero-posterior movements only are possible.

The theory is that a rapid re-adaptation of structures to the altered conditions occurs. In practice, however, it is chiefly stretching of the soft parts which results, and prolonged after-treatment is needed. It is also a serious error to suppose that no after-treatment is needed where osteoclasis or osteotomy has been performed, whatever the ardent advocates of these procedures may say.

The procedure of Lorenz is to obtain rectification by means of his osteoclast at one sitting. He does not aim at fracturing the bone, and the correction which occurs is chiefly at the expense of the soft parts. At least twelve months' after-treatment is needed to cure the lax joint which follows. This method is not to be commended, and has wisely been abandoned by its author. It is mentioned here in order to aid the conception of the principles on which rational treatment is based.

The most tedious cases of genu valgum occur in children, often with a rickety taint, with general relaxation of the muscles and ligaments, the knee-joints being almost flail-like. Such cases are entirely unsuitable for operation, and their legs require supporting apparatus, with thorough massage of the muscles and joints, until the improvement in the general health and the local conditions permits them to relinquish the apparatus; but this may not occur for twelve months or even two years. It is futile to allow them to run about with these weak joints unsupported, as the deformity

[1] *Deutsche med. Wochenschr.*, 1889, No. 1. ; *Centralbl. f. Chir.*, 1890, p. 340.

rapidly gets worse. In many instances supports by day and long outside splints by night are called for.

Operative Measures are, (1) Osteoclasis, (2) Epiphysiolysis, (3) Osteotomy.

1. **Osteoclasis.**—In order to avoid the dangers arising from a compound fracture, as in osteotomy, various procedures have been advocated. In the pre-aseptic era the difference between a simple and compound fracture was of vast importance. Although from that point of view osteoclasis has nowadays almost lost its value, yet experience has shown that it has incidentally certain advantages which have prevented its falling into entire disuse. One is rapidity of performance, the actual fracture of the bone with the osteoclast taking only a few seconds. The pain after osteoclasis is less, and it is stated that union is more speedy and certain. In some cases, very few it is true, where the "logical" point of correction is at a spot where osteotomy is difficult and dangerous, osteoclasis is distinctly the method of choice.

Manual Osteoclasis—Forcible Manual Correction.—In a limited number of cases it is possible to fracture the bone manually, as advocated by Délore and Tillaux.[1] For genu valgum this method of osteoclasis has several disadvantages, and no advantage, for the bones of even young children may be so prematurely eburnated that it is impossible. If the leg is used as a lever in fracturing the lower end of the thigh, rupture of the external lateral ligament and partial dislocation may result.[2] If the surgeon does not use the leg as a lever, he attempts to operate by grasping the condyles only, and in this case failure is the rule. The fracture produced by manual osteoclasis may be oblique, comminuted, or in the wrong place. In experiments on the cadaver separation of the epiphyses of the femur and tibia, rupture of the periosteum, and laceration of the external lateral ligaments have been produced.[3]

To obviate these disadvantages various osteoclasts have been invented, all of which follow one of two principles, the differences being in matters of minor detail. In the one class the limb rests against two bars, and is fractured between them by a bar driven by screw power (Grattan's, Rizzoli); or by lever power (Walsham's), the bone being broken as a stick is snapped across the knee. In

[1] Quoted by Berger and Banzet, *Chir. Orth.* p. 402.

[2] Möhring (*Zeitschr. f. orth. Chir.* vol. iii. p. 201) reviews Zuffi's method of forcible manual correction. This author says, however, "The method is safe and sure, and relapses are rare. In 800 cases the external lateral ligament was never ruptured."

[3] Barbier, *Étude sur le genu valgum*, Thèse de Paris, 1874.

the other class the principle of a lever of the first kind is involved. The limb is firmly fixed in a clamp, and by leverage applied to its free segment it is fractured opposite the lower end of the clamp which serves as a fulcrum. It is immaterial whether the actual power is applied to the limb by a screw (Lorenz' Osteoclast) or by lever power (Robin, Taylor). Of all osteoclasts Grattan's is the best (Fig. 486). It is solid, simple, accurate, easily regulated, equal in action, and quick in release. The fracture-wedge is screwed home and is liberated so quickly that the soft parts escape damage. The arms against which the limb rests can be approximated as desired.

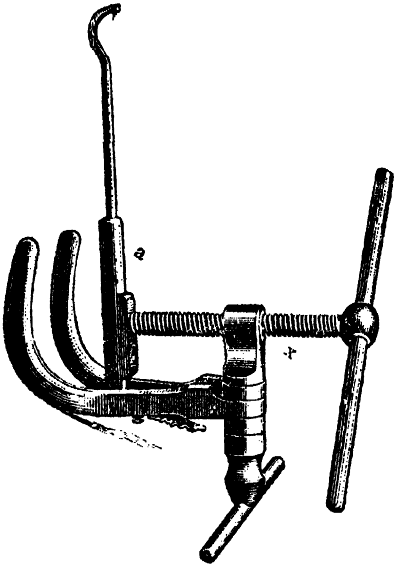

FIG. 486.—Grattan's Osteoclast.

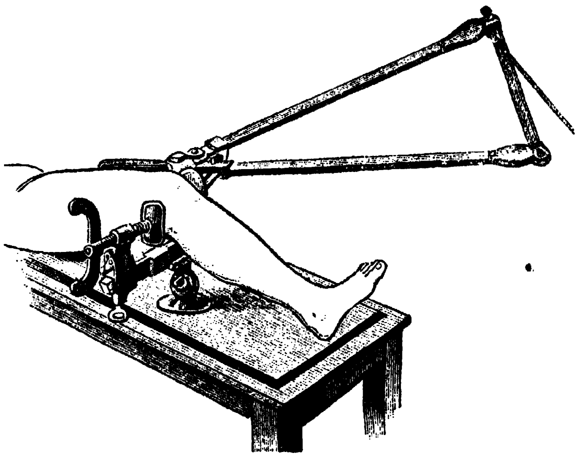

FIG. 487.—Colin's Osteoclast.

In another class the upper segment of the limb is held firmly as in a vice, the lower edge of which forms a fulcrum, against

which the bone is fractured, the power being applied by leverage, as in Robin and Colin's apparatus (Fig. 487), or by screw power, as in Ferrari's and Lorenz'.

The operation of osteoclasis has practically no mortality. Fat embolism—fortunately rare—may be met with in this, as in any fracture. With improved appliances and extended experience undesirable complications are seldom met with. The accidents which may happen are separation of the epiphyses and temporary effusion into the joint, or tearing of the external lateral ligaments, perhaps with avulsion of a fragment of the external condyle. Injuries to the skin and soft parts are quite exceptional, and so far no case of damage to the popliteal artery has been recorded. Defective union may follow, owing to the presence of florid rickets, general malnutrition, or improper after-treatment.

As to the actual procedure little needs to be said. If the operator is nervous about the epiphyses, and Grattan's osteoclast is being used, the resistance bars can be so placed as to avoid the epiphysial lines, and even if an epiphysis is displaced, no interference with growth takes place. This fact is demonstrated by the results of the method known as :—

2. **Epiphysiolysis.**—The epiphysis is slightly displaced laterally on the diaphysis. The separation is effected by clamping the limb to the edge of a table in such a manner that the thigh is firmly held, the knee and leg are free, and the lower edge of the clamp or fulcrum is exactly opposite the epiphysial line. The operator then, by using the leg and knee as a lever, effects the desired redressment.

This operation requires consideration from three points of view. First, does the break of continuity actually take place at the epiphysial line? Secondly, can the effect on the subsequent growth of the bone be entirely discounted? Thirdly, if these points are satisfactorily solved, what advantages are there over the well-tried osteotomy?

The general trend of opinion is that dislocation of an epiphysis is by no means easy, and Wallace Blanchard,[1] carefully following Reiner's directions,[2] failed to produce it. In *rédressement forcé*, either during life [3] or on the cadaver,[4] separation of the epiphysial

[1] *Trans. of Amer. Orth. Ass.*, May 12, 1903.

[2] *Zeitschr. f. orth. Chir.* Bd. xi., and Joachimstal, *Handb. f. orth. Chir.* vol. ii. pp. 367-368.

[3] Berger and Banzet, *Chir. Orth.* p. 402.

[4] Barbier, *op. sup. cit.* p. 647.

line is recorded as a rare accident, whereas fracture of the diaphysis, in attempting epiphysiolysis, is not uncommon.[1] The femur in children is much narrowed immediately above the epiphysial line, and therefore gives way more readily. It is not clear that separation at the epiphysis is either easily or certainly effected.

As to the result on the growth of the limb, this need not give rise to anxiety.[2] Continental surgeons are less apprehensive on this point than English and American. About such a simple matter there could be no room for discussion, if shortening were a common event. Epiphysiolysis then is free from any special risk, but is not so easy to carry out as its advocates suggest. It offers, however, the advantages of ease, simplicity, and avoidance of any possibility of septic infection. The amount of displacement required is only such as to reduce the deformity, and on account of the anatomical arrangement of the parts there is no risk of overriding of the fragments. The adaptation being so close, early union is assured. It can be performed in children and young adolescents up to the age of seventeen years, and, if it fails, the patient can be treated later by osteotomy.

The chief disadvantage is that in carrying out this method the knee-joint is liable to be sprung.[3] It should be remembered, however, that cases of osteoclasis or epiphysiolysis call for supervision and support for at least a year after the operation. We have seen genu varum result from neglect of this precaution.

The general opinion as regards operations for genu valgum is that the choice rests between osteotomy, particularly MacEwen's operation, and in suitable cases osteoclasis. Very rarely is a limb seen in which Ogston's procedure can be satisfactorily employed, and operations on the upper end of the tibia are not generally attempted. Personally the writer prefers to perform osteotomy by a modification of MacEwen's method.

3. **MacEwen's Supra-condylar Osteotomy.**—The skin is duly asepticised. The patient lies on his side, and the knee is somewhat flexed with a sandbag beneath the lower part of the thigh. Two osteotomes (Fig. 488) should be at hand, one half an inch and the other three-quarters of an inch wide.

[1] Lüning and Schulthess, *Orth. Chir.* p. 506.

[2] Codivilla discusses this thoroughly in the *Revue d'orth.*, March 10, 1906, basing his remarks on 2000 cases.

[3] For further information on epiphysiolysis Codivilla (*Zeitschr. f. orth. Chir.* Bd. xi., and *Bull. della scienza med.*, 1905) should be consulted.

The point of incision through the skin is on the inner[1] side of the thigh, half an inch in front of and one inch above the adductor tubercle. A long narrow-bladed knife is entered on the flat at this spot, and carried straight down to the bone,[2] and divides the periosteum on its anterior and internal aspects. With the heel of the knife the incision is enlarged longitudinally to a little more than the width of the osteotome. Along the knife as a director, the osteotome is introduced and is passed to the bone, the knife being then withdrawn. The osteotome is then turned at right angles to the limb. By successive blows of the mallet the osteotome, held firmly (Fig. 489), is driven through the inner two-thirds of the bone. Mr. Jacobson[3] says: "The direction of the bone incision is most important. The surgeon must cut transversely across the femur on a level with a line drawn half an inch above the top of the external condyle. This incision will avoid the epiphysis and synovial membrane. The line of the former may be usually represented by one crossing the femur at the level of the highest point of the femoral articulating surface, and running through or just below

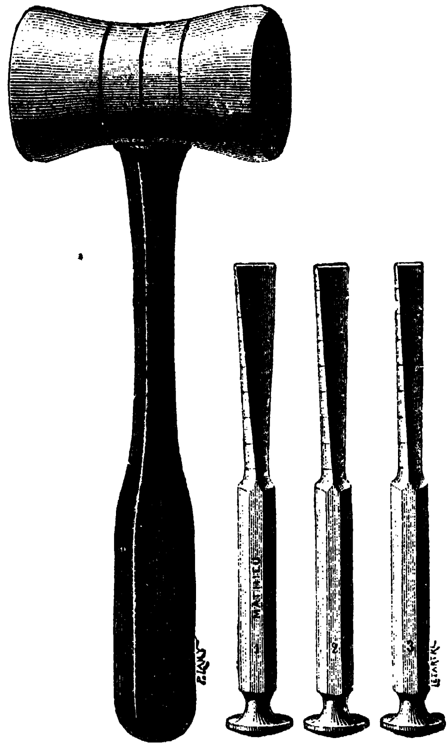

FIG. 488.—Osteotomes and Mallet. The latter, however, is now made of steel, with lead-insertions at the sides of the mallet-head, to cover the striking areas.

[1] Gussenbauer works from the outer side. This is not so satisfactory as MacEwen's plan, because the osteotome, by compressing the bone, makes a gap of a wedge-shape with the base internally (in MacEwen's), and it is on the inner side that the gap is most needed.

[2] Some surgeons drive the chisel right through the skin, and use no bistoury.

[3] Jacobson and Rowlands, *The Operations of Surgery*, 5th ed. vol. ii. p. 1067.

the adductor tubercle, so that the incision being an inch above the tubercle, the epiphysis will be cleared. The only part of the synovial membrane which is as high as the bone incision is that under the quadriceps, which may reach in the adult as high as two inches above the trochlear surface. There is generally a quantity of fat between it and the bone. The spot selected by Sir W. MacEwen for his incision is posterior to this point. As in a valgous limb the whole internal condyle is lowered, a line drawn transversely from the adductor tubercle might land the operator low down in the external condyle. The osteotome, placed against the inner edge of the bone, must be driven at first from behind forward and to the outer side. It is then made to move forwards along the inner border until it comes to the anterior surface, when it is directed from before backward and toward the outer posterior angle of the femur. By keeping on these lines there is no fear of injuring the artery." After each blow of the mallet the handle of the osteotome must be moved laterally, so as to prevent locking. In view of this contingency the employment, first, of a large and then of a small osteotome is to be commended. When three-quarters of the bone have been divided the limb is extended, and with one hand just above the wound and the other holding the middle of the leg, the limb is carried steadily inwards until the femur is felt to give. Difficulty often arises owing to the external or posterior aspects of the femur not having been sufficiently divided. The osteotome must then be re-introduced, but it is a bad proceeding. Owing to the retraction of the soft parts, it is often by no means easy to make the osteotome enter the incision in the bone.

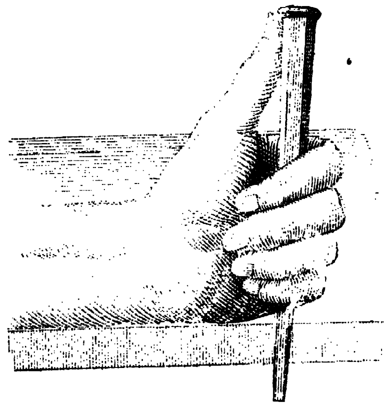

FIG. 489.—Mode of grasping Osteotome (Bradford and Lovett).

The wound is closed and dressed, and put up in splints in the straight position. Personally we prefer to place the limb on a back and two side splints for the first ten days; then to remove the splints and rectify the position completely, and to encase the

limb in plaster of Paris bandages.[1] Eight weeks after the operation the plaster is taken off and the patient allowed to walk on crutches. As a rule no difficulty is experienced from the stiffness of the knee-joint. It is not necessary to break the joint down forcibly, but with use movement gradually returns.

In bilateral genu valgum both limbs should be operated on at the same time. In some cases simultaneous division of the biceps and ilio-tibial band is necessary to obtain good position. As to dividing the tibia below the epiphysial line, general opinion is against it. As Keetley says: "It savours too much of the fault of hiding one deformity by adding another."

The following accidents have been recorded after osteotomy. Septic infection occasionally occurs,[2] and hæmorrhage.[3] The causes of hæmorrhage are: (1) using an osteotome too broad; (2) pointing the cutting edge of the chisel backward when the posterior part of the bone is reached; (3) the chisel being allowed to slip; (4) an abnormal course of the anastomotica magna artery. Finally, the external popliteal nerve may be divided.

4. **Division of the Shaft from the Outer Side by Saw or Chisel.**—This is the procedure advocated by MacCormac. The author uses this method largely, and prefers a saw. The method of performing the operation is as follows:—

The limb is duly asepticised and rotated inwards, a sandbag being placed beneath the lower part of the thigh. The knife is entered on the outer side three fingers' breadth above the patella when the limb is extended and mid-way between its anterior and posterior aspects. It is passed straight down to the bone, and cuts firmly on to its anterior and outer surfaces, so as to divide the periosteum. With the heel of the knife the wound is enlarged backwards. Along the knife, now turned on to the flat, the saw is introduced. At first the handle should be dropped a little so as to divide the outer wall of the compact tissue. It is then raised somewhat and

[1] Keetley remarks: "The exact amount of looseness of the knee-joint, if any, should be noted before the bone is divided, and allowed for in putting up the limb. To this end the adjustment will sometimes have to be in a position of distinct varum."

[2] Sir W. MacEwen (*Lancet*, Sept. 27, 1881) collected 1384 cases, of which 820 were his own. Three died after the operation, 2 from septicæmia.

[3] M'Gill (*Lancet*, May 17, 1884) reported a case in which the popliteal artery was divided, and was subsequently ligatured. Langton (*ibid.* March 29, 1884) mentions wound of the popliteal artery by a sharp spicule of bone projecting at the site of fracture. Considerable hæmorrhage occurred. The artery was ligatured. Gangrene set in, and amputation of the thigh was performed. Unfortunately, however, death ensued.

cuts through the anterior and part of the inner wall. In this way at least two-thirds of the bone is divided. By carrying the leg firmly inward, the thigh being held, the thin posterior wall readily gives way. The wound is then dressed. For the first ten days

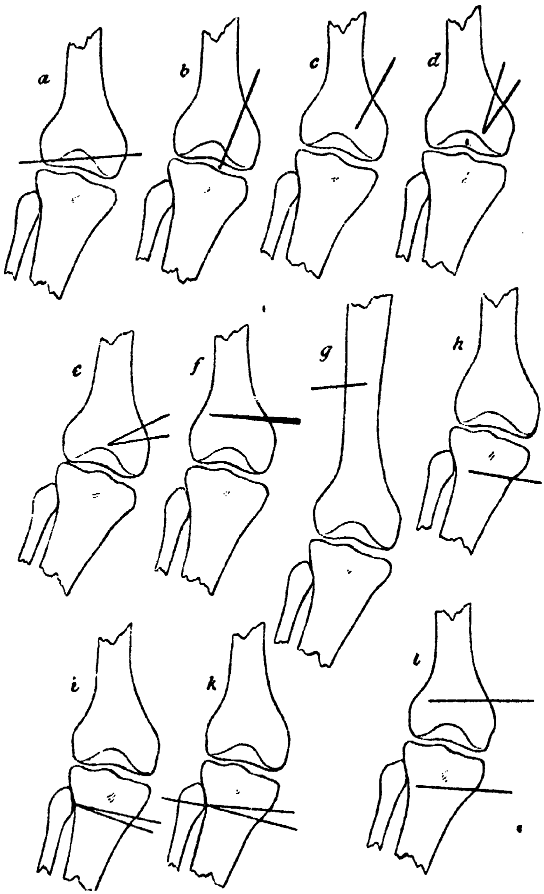

FIG. 490.—Forms of Operation for Genu Valgum (Binney):—*a*, Annandale; *b*, Ogston; *c*, Reeves; *d*, MacEwen's cuneiform Osteotomy; *e*, Chiene; *f*, MacEwen's supracondyloid Osteotomy; *g*, Reeves; *h*, Billroth; *i*, Mayer; *k*, Schede; *l*, Barwell.

the writer places the limb on a back and two side splints. At the end of that time the position is finally rectified and the limb placed in a Croft's splint or plaster of Paris bandage. The plaster is removed at the end of the sixth week, and the patient is allowed to go about on crutches.

Advantages.—Mr. Jacobson states that the advantages are: "1. The femur is divided at a much narrower part than in the supra-condyloid operation of MacEwen, and thus it is easily and most quickly done. 2. The bone section is farther away from the epiphysis and the line of synovial membrane, in case subsequent inflammation takes place. 3. There are no important blood vessels near."

5. **Oblique Division of the Internal Condyle** (Ogston).—The limb is flexed and supported on a sandbag. A narrow-bladed knife is entered at the mid-point of the inner aspect of the thigh and two inches above the adductor tubercle, and is then carried downward and outward firmly on the bone, until the point is felt in the intercondyloid notch. As the knife is withdrawn the skin-opening is enlarged. Using the knife as a director, an Adams saw is passed along it and the edge of the saw turned backward. The internal condyle is then nearly sawn off. When the saw approaches the posterior part of the bone it is withdrawn. By carrying the knee firmly inward, the internal condyle is detached and slips up somewhat on the inner surface of the femur. The wound is dressed and the limb is placed either in wooden splints or plaster of Paris bandages.

The operation is of value only in very severe cases of knock-knee, when the deformity is entirely due to great elongation of the internal condyle, and it is evident that a linear osteotomy will not suffice to rectify it.

Disadvantages.—1. Stiffness of the joint has followed. 2. The knee is freely opened and its structures considerably disturbed. 3. The risks involved in any want of care in securing perfect asepsis are very serious. 4. Genu varum may follow, owing to the portion of bone chiselled away becoming too much displaced upwards. Mr. Reeves claims that by his modification [1] of Ogston's operation the joint is not opened. He adds, however, "Granting, for the sake of argument, that the joint is always opened in these cases, experience has abundantly shown that practically it matters not, and in this case the operation is properly called extra-articular." [2] 5. Interference with the epiphysial cartilage may lead to retardation of growth. This has been recorded.[2]

[1] Partial division of internal condyle by chisel, and completion by forcible straightening.

[2] *Bodily Deformities*, pp. 274-275. G. Melloni has declared his preference for Mr. Reeves' operation over MacEwen's, as it completely avoids the difficulties arising from vicious union of fragments or from incomplete union, which, according to Melloni, sometimes occur in the latter operation.—*New York Med. Rec.*, May 1894, p. 638.

To *sum up* the treatment of genu valgum. 1. Cases under four years of age should be treated by manipulation, splints, and mechanical appliances. Operative interference is not called for.

2. Cases over four years of age fall into two classes: (*a*) Those in which malposition of the limb is entirely due to relaxation of the ligaments, but with little overgrowth of the internal condyle. (*b*) Those in which the internal condyle is much enlarged, or the lower end of the femur twisted inwards, and the bones are eburnated.

In (*a*) local rest, massage, splints, or walking apparatus will effect a cure.

In (*b*) treatment by mechanical means is possible but tedious. It is better to operate, and to perform an osteotomy of the femur from outside, after preliminary section of the biceps and ilio-tibial band, if they are contracted.

CHAPTER XII

GENU VARUM, BOW-LEGS, AND GENU RECURVATUM

Definition—Frequency—Causation—Varieties—Prognosis—Treatment.

Synonyms—English, *Bandy-legs, Out-knee*; Latin, *Genu extrorsum*; French, *Genou en dehors*; German, *Sichelbein, Säbelbein, O-Bein.*

Definition.—Genu varum is that condition of the legs in which a line drawn from the head of the femur to the middle of the ankle joint falls inside the centre of the knee-joint (MacEwen).

Frequency.—Genu varum is a condition very often seen. According to Whitman[1] this deformity and knock-knee comprise about 15 per cent of the cases met with in orthopædic practice. The occurrence of bow-legs is 50 per cent greater than that of knock-knee. Unilateral bow-leg is said to be a rarity, but Kirmisson collected 290 cases of curvature of the tibia of all kinds, and 38 were found to be unilateral. Bow-leg rarely starts after childhood. It may become exaggerated if present from infancy, but practically all cases met with in adults are traceable to early life.

It is found expedient to describe genu varum and bow-legs together. In genu varum the curvature is distributed throughout the whole length of the limb, and the deformity is most marked at the knee, which is the point where the curve attains its greatest sweep outwards. Bow-legs may exist without genu varum, but not genu varum without bow-legs.

Genu varum cannot be considered in all points as an exact antithesis to genu valgum. The one point of contrast is that in genu valgum the knees are displaced inward, in genu varum they are displaced outward.

Causation.—Bow-legs are not only met with in obviously rickety cases, but also in children in whom no signs of general rickets can be detected. It cannot be divided into infantile and

[1] *Orthopedic Surgery*, 2nd ed. p. 553.

adolescent forms,[1] as genu valgum. In some instances a relaxation of the ligaments of the knee-joint, especially in adult cases, is found. The greater frequency of genu varum, as contrasted with genu valgum, may be in part explained by a habit of young children of sitting tailor-fashion on the floor.

The author has eight times seen genu varum occurring after operation for genu valgum, in which suitable after-treatment had been neglected. In one remarkable case, a Russian Jew had

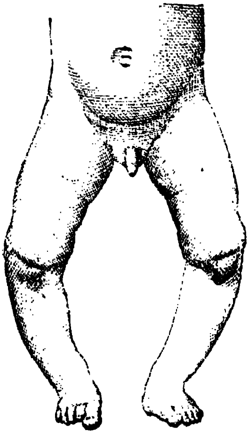

FIG. 491.—Genu Varum of Rickety Origin (Rédard).

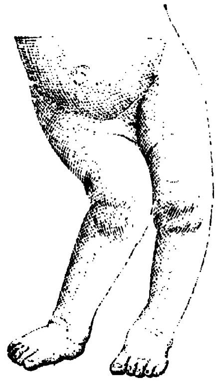

FIG. 492.—Genu Varum in the left limb complementary to Genu Valgum in the right limb (Rédard).

undergone two operations on each leg before he came under his care. The original condition was genu valgum. This was operated upon, and genu varum followed. A second operation was performed for genu varum on the Continent, and genu valgum resulted. The patient was quite clear that no supports whatever had been applied to his legs when the plaster of Paris had been removed after each operation. The author performed a third operation for genu valgum, and the difficulty of dividing the bones was extreme, on account of their intense hardness. The limbs were straightened, and the patient is now under careful observation, wearing proper steel supports.

Varieties.—In both genu varum and bow-legs the knees are apart when the ankles touch, and the feet are often in a position of

[1] Genu varum coming on in adolescence is a rarity. Rédard (*Chir. Orth.* p. 591) describes a form of epiphysiary genu varum, commencing chiefly in girls between the ages of twelve and sixteen.

compensatory valgus. But, whilst in true bow-legs the curvature is chiefly confined to the tibia, in genu varum the knee is at the summit of the curve, which is distributed over the bones of the limb. Bow-legs may be present without any genu varum, and occasionally in combination with genu valgum.

The tibial curve which is often met with in genu varum is

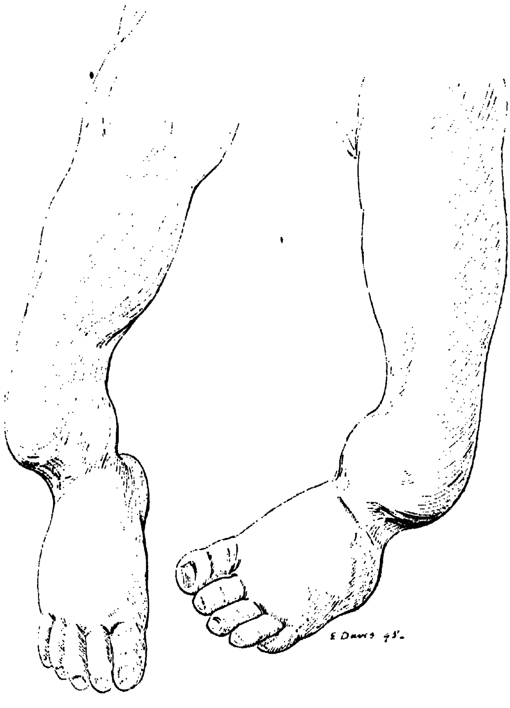

FIG. 493.—Sinusoidal Curvatures of the Tibiæ.

sinusoidal. This is not a mere bowing, but a double curve inwards above and outwards below (Fig. 493).

Prognosis.—In moderate cases, where rickety eburnation is not marked, considerable spontaneous improvement may be anticipated, at all events up to six years of age; but careful examination will in most cases of so-called spontaneous cure enable one to detect some deformity. The prognosis is, however, better than in knock-knee.

Treatment.—The treatment may be (1) Expectant; (2) Mechanical; (3) Operative—(*a*) by Osteoclasis, (*b*) by Osteotomy.

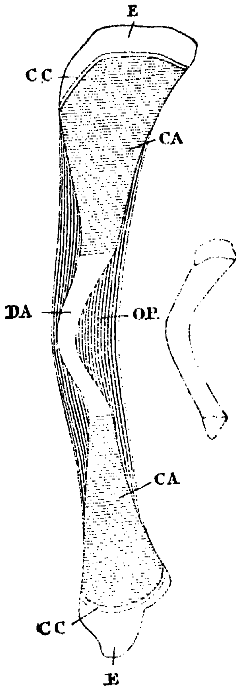

FIG. 494.—Scheme to illustrate the Spontaneous Rectification of Rickety Bones during Growth (Ollier). The small figure on the right represents a Rickety Tibia in a young child. The large figure is the same bone in an Adolescent, and the small figure DA is now inscribed within the large space occupied by the Shaft of the Primitive Bone which has disappeared in the Progress of Development; CA, CA, the Additional Bone due to Ossification at the Epiphysial Lines, which were in a Right Line with the Shaft during the attack of Rickets. This new Bone CA forms two Cones, of which the Apices correspond to the extremities of the Diaphysis of the Infantile Bone. They enlarge *pari passu* with the growth of the Bone. OP, Periosteal Bone, by means of which the Bone becomes thicker and the former Shaft is gradually enclosed. EE, Epiphyses. CC, Epiphysial Lines.

1. *Expectant.*—This comprises general treatment for rickets, the deformity being left to rectify itself (Fig. 494). It is sometimes suggested that the child should be kept as much as possible off its legs, but cases in which increase of the deformity may be anticipated if the child is allowed to go about are not suited to expectant treatment. If the child is not allowed to run about, how can the effect of muscular action and of normal function in reforming the part come into play? In any case careful tracings, taken every few weeks, should be made.

2. *Mechanical.*—This form of treatment is called for when a curve, originally slight, has become marked; when a child is weighty, and cannot be kept off its legs; when the curve is localised to one part of the leg more than in another; and when the child is under four years of age, and the bones are not hardened.

The question arises: Should the form of apparatus be such as to entirely prevent the child walking? I think not in any case. All forms of apparatus act on the principle of taking their fixed points above and below from a bony prominence, and drawing the curve towards the support. Provided this is efficiently done, the child should be allowed to use his legs, as free movement encourages that improved nutrition which more than counterbalances the effects of the body-weight.

The simplest form of apparatus for bow-legs is an inside wooden

splint from the internal condyle to the inner malleolus. The same principle exists in more complicated apparatus. In genu varum the whole length of the limbs must be controlled. This can be effected by a single inside steel (Fig. 495) passing up the whole length of the limb, and then curving out along the groin and below the iliac crests. It is attached to a foot-piece by means of a joint opposite the ankle. Pressure is brought to bear upon the limb by means of straps and a leather knee-cap.

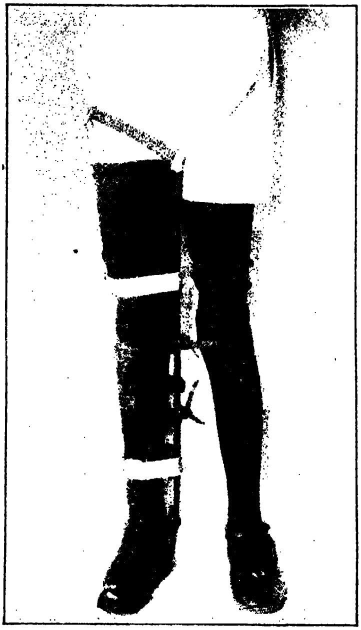

FIG. 495.—Inside Steel-Support with Knee-Caps as used by Bradford and Lovett.

3. *Operative.—Osteoclasis.*—This is of great value in the treatment of bow-legs, except when the curvature is markedly anterior, and has decided advantages over osteotomy. Osteoclasis should be employed when the bones are so hard that mechanical treatment is out of the question, when the deformity is marked, and in children over three years of age. Osteoclasis can be used for curvature at the upper part of the tibia, whereas osteotomies in that region are by no means free from anxiety. Manual osteoclasis is of the greatest value in the treatment of curvatures of the tibia in children under three years of age. It is performed under an anaesthetic, either with or without the use of a wedge. If without a wedge, the surgeon notes the point of greatest curvature, and firmly grasps the limbs with the hands above and below that point. The thumbs are then placed side by side over the point and used as a fulcrum. The limb is then straightened until it snaps. It is not sufficient to be content with mere bending, but a distinct snap must be felt and heard. There is no danger about the proceeding, and it is particularly useful, especially for out-patients, in whom treatment by means of splints is likely to be neglected.

Many surgeons prefer the osteoclast, and the best form is

Grattan's (Fig. 486). Blanchard, who has had considerable experience in the use of Grattan's instrument, says, "The unexampled rapidity, as well as the absence of pain, following rapid osteoclasis, the freedom from the dangers attending bloody operations, the saving of time and expense in antiseptic precautions and after-care of open wounds, the lengthening instead of the shortening of the legs of the frequently already dwarfed, are among the many undeniable advantages of rapid osteoclasis over osteotomy." In practice, accidents to epiphyses and neighbouring joints have not arisen, and subsequent union is more rapid than after osteotomy, probably because the continuity of the bone is less interfered with. Another important point, to the author's mind, is that non-union after osteoclasis is scarcely if at all known, whereas it is seen from time to time after osteotomy. The correction must be at the apex[1] of the deformity. But mere correction alone is insufficient; over-correction at the seat of fracture is necessary to compensate for the curvature above and below. Rapid union follows, and in six weeks the patient is walking on straight legs.

Osteotomy.—It is occasionally performed for genu varum, and some surgeons prefer to do a MacEwen's supracondylar operation, but entering the osteotome from the outer side. In genu varum the tibia is usually at fault, yet occasionally an X-ray photograph shows the femur to be more curved. Rarely, it may be advisable to osteotomise both the femur and tibia. They may be done simultaneously, but it is safer to operate at two sittings.

Osteotomy of the tibia is simple. The limb is duly asepticised and supported on a sandbag. If it be the left leg, the surgeon stands on the left side, and passes an osteotomy knife on the flat through the skin over the crest of the tibia at the most prominent point of the curve, and down over the inner surface of the bone. He then turns the knife at right angles, and divides the periosteum. The saw is introduced along the knife, and as the former is withdrawn the skin incision is enlarged so as to prevent the heel of the saw abrading it. With short movements the tibia is divided, taking care not to wound the structures posterior to it. There is no necessity to divide the fibula. When the section of

[1] Blanchard uses the word apex, regarding the limb as a whole. If the tibia alone is involved, in the majority of cases the sharpest bend is at the junction of the lower third and upper two-thirds. But even if this fact be fully recognised, the contour of the limb is best restored by osteoclasis high up in the tibia, at the junction of the upper third and lower two-thirds, and this point is called the "apex" by Blanchard.

the tibia is nearly complete, a quick, firm movement inwards or outwards, as the case may be, will fracture the fibula and the remaining portion of the tibia. The wound is then closed by sutures, dressed, put up in plaster of Paris, and kept so for six weeks.

We have had no experience of the elaborate longitudinal osteotomy of Ollier, in which an oblique section is made across the bend, and the fragments drawn one on the other to lengthen the bone. The operation is said to be much more difficult than it looks. Very free division of the soft parts is needed if any lengthening is to take place. In our opinion it is not an operation to be recommended.

Helferich[1] has described a complicated oblique osteotomy, with sliding and rotation of the fragments, but this operation is not likely to be attempted save in the cadaver. A skilfully performed osteoclasis suffices to overcome the difficulties in most cases.

Anterior curvature of the tibia is not amenable to mechanical treatment, and shows little tendency to spontaneous cure. It may be treated by wedge-shaped osteotomy or by osteoclasis, the latter being the better procedure, since it lengthens the leg, while osteotomy shortens it, and a difference of an inch or more in the case of a patient already dwarfed is a matter of great importance. This lengthening is preceded by division of the tendo Achillis. In attacking the lateral curve, the fracturing bar of the osteoclast is directed against the prominence of the curve, but in dealing with anterior curvatures, if we direct the force immediately against the skin over the crest of the tibia the result is disastrous. In severe cases the tendo Achillis is divided first, and the bone is broken from the side in the direction of least resistance. Then the parts are straightened manually. This leaves a wedge-shaped gap posteriorly, which fills in with callus. The plaster of Paris casing must be well and strongly made, so as to hold the fragments in good apposition.[2]

Cuneiform Osteotomy.—Before this is done, the size of the wedge to be removed should be determined by drawing an outline of the bend as seen in an X-ray photograph on paper; and then removing with scissors a sufficient wedge from the paper, so that the curve may be rectified. In this form of operation the osteotome

[1] Joachimstal, *Orth. Chir.* p. 397.

[2] Blanchard's articles on this subject, which are numerous and lengthy, will repay perusal. They are as follows :—*Trans. Amer. Orth. Assoc.* vol. xiv., 1901, p. 153 ; *Chicago Med. Rec.*, 1901, xviii. pp. 453-466 ; *Amer. Jour. Orth. Surg.*, Aug. 1903.

is preferable to the saw. Some difficulty is experienced after excision in bringing the leg straight. This arises from two causes—(*a*) The periosteum on the posterior surface of the tibia is imperfectly divided; (*b*) In cases of considerable anterior curvature the tendo Achillis is too short, and prevents apposition of the fragments, and should therefore be divided.

Genu Recurvatum

Synonyms—English, Back-knee; French, *Génou en arrière.*

Definition.—A deformity characterised by hyper-extension at the knee-joint.

Occurrence.—It is seen associated with other conditions:—

1. Congenital club foot, *e.g.* equino-varus and valgus. In some of these cases the patella is absent or is rudimentary. If a nodule in the place of the patella can be felt, it is found that if the genu recurvatum is prevented, and the parts well massaged, the patella ultimately develops to full size and usefulness.

Fig. 496.—Genu Recurvatum due to Infantile Paralysis (Rédard).

2. Infantile paralysis (Fig. 496).
3. Rickets, on account of the relaxation of the muscles and ligaments.
4. Deformities of one limb, where excessive strain has been put upon the sound limb.
5. Charcot's disease.
6. As a primary condition in congenital dislocation of the knee.

Humphry has also described a condition of back-knee, the result of irregular growth of the upper epiphysis of the tibia, due to chronic inflammation in that situation. The posterior part of the epiphysis of the tibia becomes excessively developed.

Treatment.—Inasmuch as genu recurvatum is usually a complication of some other condition, the primary affection should be treated, but in most cases the recurvatum calls for special methods.

Whether it is due to rickets, a moderate degree of paralysis, or Charcot's disease, an instrumental support, which will not permit extension beyond the right line, is called for. In infantile paralysis experience has taught the author that the best measure is to shorten or tighten up the extensor cruris tendon, paradoxical though it may appear. To effect this, he has devised and carried out on seven occasions the following operation:—

A transverse incision, three inches in length, is made one and a

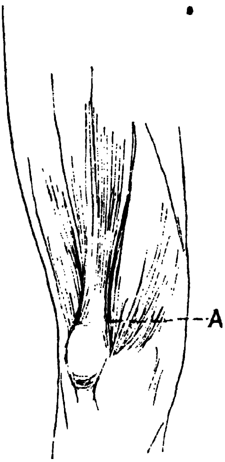

FIG. 497.

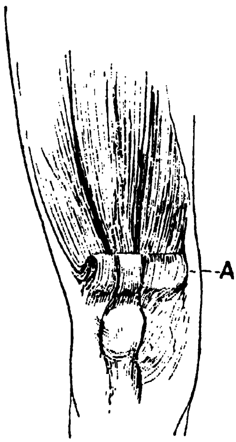

FIG. 498.

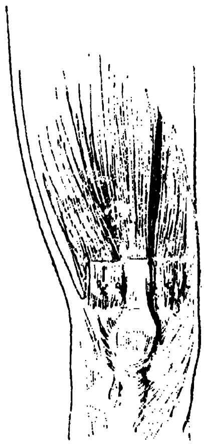

FIG. 499.

To illustrate the Author's Operation of Shortening the Extensor Cruris Muscle and Tendon for Genu Recurvatum.

FIG. 497.—The Extensor Cruris Tendon A, and Lower Part of Muscle.
FIG. 498.—These Structures are folded in a pleat at A.
FIG. 499.—The Pleat is secured and sutured at A.

half inches above the patella. The tendon is exposed, and being doubled upon itself is held so by means of toothed forceps; sutures are then passed so as to quilt it. About four to six sutures are necessary, and they should go deeply through the folds of tendon. The exact extent of the quilting is estimated by noting the effect on the tension of the ligamentum patellæ. If, with the leg extended in a right line with the thigh, the tension on the ligamentum patellæ produced by the quilting is such as to prevent the patella being laterally displaced at all, then the fold of the tendon is of sufficient extent.

CHAPTER XIII

THE STRUCTURE AND FUNCTIONS OF THE FOOT

General Structure—The "Arches"—The Foot in Standing and Walking—The Attitude of Rest and the Weak Foot—The Strong Foot—Boots and Shoes.

BEFORE we discuss abnormal static conditions of the feet, we must deal with some physiological and pathological points.

General Structure.—The foot is usually described as consisting of a longitudinal and a transverse arch. It is better to regard each foot as forming a portion of a dome. The complete dome is seen when the two feet are placed side by side, and a plaster cast taken of them in this position. In that case the astragali will form the highest part of the half-sphere.

The description of the foot as consisting of a longitudinal and a transverse arch is inapt, and the term "arch" is not correct. It cannot be said that the astragalus in any way resembles a key-stone, either in structure or function. The action of the astragalus, of its ligaments, and of the muscles which pass over or under it, is that of a reinforced girder, precisely in the same way as such is used for bridging over the space between the two piers of a railway bridge; although in the case of the foot the piers are not placed vertically, but are oblique. But the term "arch" is consecrated by long usage, and if its limitations in this connection be understood, we may retain it.

The *arches* of a foot are the longitudinal and the transverse. The *longitudinal* arch is divided into internal and external parts. The internal longitudinal arch is composed of the os calcis, the astragalus, scaphoid, three cuneiform and three inner metatarsal bones. The external longitudinal arch, smaller and shorter than the internal, the span being much nearer the ground, is made up of the os calcis, cuboid, and two outer metatarsal bones. They are braced by fasciæ, muscles, tendons, and ligaments. We shall revert more

particularly to the changes in shape of the arches under the stress of weight-bearing and of movement.

The *transverse arches* are two, the anterior, formed by the heads of the metatarsal bones when the foot is off the ground, and the posterior, composed of the astragalus, scaphoid, and cuboid. In flat foot the posterior arch yields first, and later on the anterior arch sinks; and this is one of the causes of Morton's disease, metatarsalgia, or anterior metatarsal neuralgia.

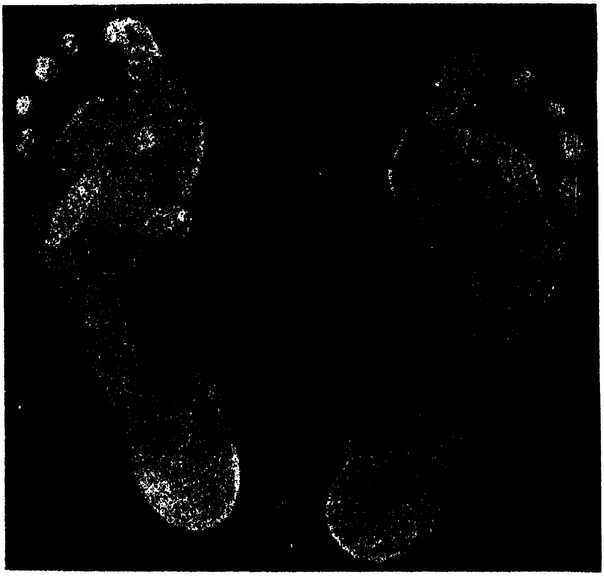

FIG. 500.—Tracing of the Soles of so-called normal feet (Bradford and Lovett).

The **functions** of the foot are two: (1) passive support in standing; (2) a lever to raise and propel the body.[1]

The Foot in Standing.—If a tracing be taken of the normal foot (see Fig. 500) it is seen that only a portion of its under surface comes in contact with the ground, namely, the heel, the outer border, and the balls of the toes. The outer longitudinal arch is therefore more solid than the inner, and its elasticity is considerably less. The inner longitudinal arch is so arranged as to provide a series of buffers to break the shock of the impact of the heads of the metatarsal bones and the toes on the ground. Thus, in jumping

[1] For many points in this article we are indebted to the excellent article in Whitman's *Orthopedic Surgery*, third edition.

the foot is always extended with this object. In standing, the weight of the body is transmitted through the tarsus and metatarsus to the heads of the metatarsal bones, which directly sustain the thrust. The heads of the third and fourth metatarsal bones form the highest part of the metatarsal arch, and when it gives way the heads of these bones are displaced lowest. And according to Whitman, "the first and fifth metatarsal bones, being more under muscular control, aid in balancing the weight and sustaining it in different attitudes." On standing, the anterior metatarsal arch is obliterated, that is, the second, third, and fourth metatarso-phalangeal articulations are depressed from their normal high positions until they nearly reach the ground. The internal border of the foot is also concave when at rest and off the ground, but on

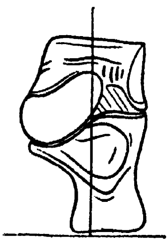

FIG. 501.—The Relation of the Astragalus to the Os Calcis (Whitman).

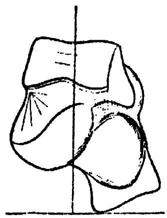

FIG. 502.—The Relation of the Astragalus and Os Calcis in Flat Foot (Whitman).

standing it loses some of its concavity inwards; and, as we know, in the weak foot it becomes flattened or even convex inwards.

There are thus considerable differences between the normal foot when it is supporting the weight of the body and when it is off the ground. Both the internal and external longitudinal arches flatten out somewhat, and the former much more than the latter. The anterior transverse arch is obliterated, and the posterior is decreased in height. At the same time the foot in front of the medio-tarsal joint undergoes some eversion or abduction. This in the normal foot is not a definite relaxation of the muscles and ligaments, but is due to the rotation downwards and outwards (see Figs. 501, 502) of the astragalus on the os calcis, until further sinking is prevented by the elastic resistance of the soft structures, particularly of the inferior calcaneo-scaphoid ligament and tendon of the tibialis posticus.

The *attitude of rest* of the lower extremities is one in which

muscular exertion is minimised. The body is thrown slightly back at the hips, so that some of the strain falls upon the strong ilio-femoral ligaments. The knees are a little apart and rotated outwards, so that the internal lateral ligament of the knee-joint is tense. The weight is transmitted through the knee-joint to the middle of the ankle-joint, and thence to the central point of the upper surface of the astragalus. It is distributed backwards to the heel, and forwards to the tarsus and metatarsus, so that the front part of the foot is turned slightly outwards, the inner part of the longitudinal arch is lessened in height, and the inner border becomes less concave. Exaggerations of this attitude of the foot at rest constitute the various degrees of weak foot and of flat foot. That is to say, an abnormally abducted foot is a weak foot (Figs. 503, 504).

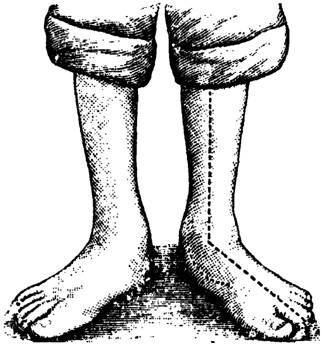

FIG. 503.—Typical "Flat Foot" of Moderate Degree (Weak Foot), illustrating the component Elements of Abduction and Depression of the Arch (Whitman).

FIG. 504.—Instantaneous Photograph of Model with Feet Everted (the Weak Foot). Posed after drawings by Whitman (Phil Hoffman).

The Foot as a means of Propulsion.—The action of the calf muscles in raising the heel and lifting the foot, so that weight is brought to bear on the heads of the metatarsal bones, is well understood. In planting the foot on the ground, as the outer border of the foot is shorter than the inner, the leg is slightly rotated outward, and the strain is directed towards the outer and stronger side of the foot. Therefore the foot is abducted temporarily and the arch sinks a little. When the foot is being advanced again, the action of the muscles and the elasticity of the ligaments is such that the eversion disappears, so that when the foot is next placed

near the ground, it should not be everted, but straight to the front. Then follows a temporary eversion as the foot touches the ground, succeeded by temporary restoration of the foot at the next step. So that in walking the attitudes of activity and rest momentarily alternate. If the patient habitually walks with his toes out, then the attitude of rest predominates, and he becomes flat-footed. A proper method of walking is therefore of the utmost importance, and children should be taught to walk with their feet nearly straight to the front.

Many people habitually keep the foot in an attitude of rest in walking, and do not voluntarily perform that slight movement of restitution of the foot inwards, so essential to perfect progression. They do not even extend the foot in walking, but come down with force upon the heel at each step. This, too, is a characteristic of the weak foot. For perfect progression the weight should be transmitted through the middle of the ankle-joint, the tarsus, and the head of the third metatarsal bone, that is through the centre of the foot.

The Movements of the Foot.—The four primary movements are dorsiflexion or flexion, plantar flexion or extension, adduction, and abduction, and the secondary movements are inversion and eversion. In inversion the sole looks somewhat inward, and in eversion outward.

Dorsal and plantar flexion are carried out at the ankle-joint. Whitman points out that "extreme plantar flexion is combined with slight adduction, and dorsiflexion with abduction, because the external facet of the astragalus allows a greater range of motion on the external malleolus than is permitted about the internal malleolus; and because the foot is in plantar flexion turned downward and inward on the head of the astragalus, and in the reverse direction in dorsiflexion." The normal range of antero-posterior movement at the ankle-joint is from 60° to 80°. The foot should be capable of dorsiflexion to an angle of 72° with the leg, and of plantar flexion to 140°. That is, there should be a range of movement of at least 60°. In Swiss guides,[1] as we have verified by measurements, this range of movement is increased by 10° to 15°. It therefore follows that they can safely ascend or descend slopes 15° steeper than most amateurs.

The medio-tarsal and subastragaloid joints permit adduction

[1] G. E. Wherry, "The Climbing Foot." This is an original and valuable contribution to the mechanics of the foot.

and abduction of the foot. Adduction of the foot is always associated with inversion of the sole or supination, and with elevation of the internal longitudinal arch, because of the shape of the joint surfaces between the astragalus and os calcis, where the greater part of the movement takes place. Motion at the subastragaloid joint consists of rotation on an axis passing from the inner part of the head of the astragalus downward and outward to the outer tuberosity of the os calcis. Therefore, adduction of the foot is accompanied by elevation of the astragalus along an inclined plane, pointing at its upper end forward and inward. This is the explanation of the accompanying inversion. In abduction the foot is everted or pronated, because the astragalus sinks downward and backward and outward along the inclined plane.

Therefore in considering both the normal and the flat foot, we must remember that adduction is always accompanied by inversion, and the longitudinal arch of the foot rises; while abduction is always associated with eversion of the foot and sinking of that arch. If these facts be grasped, the treatment of flat foot is rendered quite simple and rational. A limited degree of adduction and abduction, and flexion and eversion, is possible in the medio-tarsal joint, but the range of movement is much less here than in the subastragaloid joint.

The positions of activity and strength of the foot are adduction and inversion; the positions of weakness are abduction and eversion. During activity in a normal person the position of strength prevails, and during rest there is a slight reversion to the position of weakness. That is, the foot is tilted over slightly towards its inner side, and the sole is everted, whilst the incidence of the weight shifts from the outer towards the inner edge of the foot.

It is unnecessary to discuss fully the functions of the muscles, except to remark that the structures which maintain the inner longitudinal arch are the tibialis anticus and posticus, the flexor longus pollicis, and the inferior calcaneo-scaphoid and calcaneo-astragaloid ligaments. The peroneus longus and brevis support the outer arch, and the peroneus longus strongly assists in maintaining the posterior transverse arch. The short muscles also serve to knit together the various bones.

Boots and Shoes

In the chapters on Flat Foot, Morton's disease, and Hallux Valgus, we trace the effect of improper boots in their production. It must not

be assumed that the patient is always at fault; more often it is the man who makes the boots. We constantly hear the remark, "Oh, I have had my boots made specially for me." And there is considerable evidence to show that even when a patient is carefully measured for boots and has a "last" made for him, the workman forthwith adapts the "last" so as to turn out, not a properly shaped boot, but a fashionable one. In fact, he literally compels the foot to fit the boot, instead of the reverse. Of course all blame does not rest with the bootmaker. Many ladies who suffer agonies from their feet will not allow a proper boot to be made. Indeed, some regard the natural foot as the most unsightly part of their anatomy.

The points of support in the foot are the heel and the head of the first and of the fifth metatarsal bones with the soft tissues between them. It should also be remarked, when the foot is placed on the ground its breadth increases and the arch descends. Now the common faults in boots are: (1) that they are too narrow; (2) the heels are too high; (3) there is not sufficient support in the waist of the boot; (4) the soles of the boots are often too thin; and (5) they are frequently convex from front to back, or "rocker" like, and are often convex downwards from side to side; (6) the depth of the upper over the great toe is too little, so that this digit is not free to move; and (7) they are often too short. In walking, the foot should be brought straight to the front, and in order to do this the great toe must have absolutely free action.

FIG. 505.—A very usual and bad Type of Boot (Phil Hoffman).

In adducting the foot the great toe is always flexed; and unless there is room for this action, adduction will be imperfect. The foot may be passively adducted by pressure on three points: on the outer side of the head of the fifth metatarsal bone, on the external aspect of the heel, and on the inner side opposite the medio-tarsal joint. It therefore follows that the outer edge of the sole should be convex, and the inner edge concave, or, to put it more precisely, the front part of the boot should have a distinctly inward twist. This permits the adduction not only of the foot but also of the great toe. The angle of lateral and inward deflection of the boot should be the same as that of the foot. The width of the sole should be a little more than that of the foot when the whole weight of the foot is thrown upon it.

Most people wear heels too high. In childhood they are unnecessary because they limit freedom of movement at the ankle-joint; but in adult life a heel is useful, as it makes walking easier by inclining the body somewhat forward. In any case the height of the heel should not exceed one inch. The high heel is not only an insecure support, but

PLATE XXXI.

Skiagram showing compression of the left foot by boot (Bradford and Lovett).

To face page 672.

leads to right-angled contraction of the tendo Achillis. It also pushes the foot forward at the narrowest part of the boot towards the point, and results in deflection outwards of the great toe and cramping of the small toes. The waist of the boot should be firm and fit closely to the arch in the adducted foot; the sole should be thick enough for protection, flat from side to side, and should not curl up in an antero-posterior direction. This "rocker" sole prevents freedom of action of the toes, and in time leads to permanent dorsiflexion and contraction of them. Further, there should be no curve or spring in the sole. It ought to be plane from side to side, so that the heads of the second, third, and fourth metatarsal bones do not descend below the level of the first and fifth. A boot sole convex from side to side is a frequent cause of anterior metatarsalgia. Over the toes the upper leather should be capacious and deep, to permit the normal activity of the toes and the slight adduction of the great toe.

Patients who have for long worn the ordinary boots find it impossible to revert without serious discomfort to physiological boots, and therefore resort to unscientific boots with square toes. But as it is the part of the boot which covers the foot, and not that which lies beyond it which is of importance, this change of shape does not help them. It is found in practice that people with the ordinary deformed foot of an adult get on better with an improved rather than a perfect physiological shoe.

When there is a marked tendency to abduction of the foot it is always a wise precaution to make the inner edge of the sole and heel one-eighth inch thicker than the outer, or, as it is technically called, "using a Valgus Wedge."

Socks

Whenever possible it is advisable to have the socks made right and left. However, this is an expensive business, and, provided the socks are made of soft material and are not narrow, the natural action of the toes is not retarded.

CHAPTER XIV

STATIC FOOT TROUBLE (FLAT FOOT)

The Weak Foot, the Flat Foot, and the Pronated Foot

General Considerations—Predisposing Causes—Frequency—Intrinsic Causes—Symptoms—Types of "Flat" Foot—Pathology and Morbid Anatomy—Prognosis—Diagnosis—Treatment.

In recent years a large amount of work has been done by observers on the various forms of static foot trouble, which has resulted in a considerable widening of the generally accepted views on flat foot. The two most important points brought out by modern research are—

1. The behaviour of the normal foot under the influence of weight.

2. The effect of a frequently repeated position in producing structural adaptation.

We shall see that the typical flat foot is an advanced stage of the pronated or abducted and everted foot. Yet every pronated foot is not to be regarded as an inevitable stage in the development of flat foot. The pronated foot is in its early stages the stereotyping of a phase in the behaviour of a normal foot under weight. The readiness to pronate and the degree of pronation is a measure of the weakness of a feeble foot. Further, although every flat foot is a weak foot, we must not accept "flattening of the arch" as necessarily the first, or indeed always an early, sign of flat foot. To be more precise, we should have said "abnormal flattening," since a temporary loss of the arch is to a certain degree an integral part of the complex movement spoken of as pronation.

It is evident, then, that a concise definition of the expression static foot trouble is impracticable. We cannot express it in terms of the deformity present, because this is of too variable a character, and in many cases of static trouble severe subjective symptoms are

present without any obvious departure from normal form. Again, the degree of subjective symptoms present does not help us, because marked flat foot may exist without any pain or serious disability. Nothing, then, short enough to be called a definition, yet wide enough to cover the whole ground, can be given.

We suggest, then, that the idea involved by the somewhat loose term of "static foot trouble" will by its very vagueness enable us to discuss under the one heading weak foot, flat foot, painful flat foot, pronated foot, weak ankles, painful foot, splay foot, broken-down foot. Perhaps the term "overweighted foot," bearing in mind that the overweighting is only relative to the feet in question, is useful on account of its ætiological significance.

FIG. 506.—An Example of one Type of Static Foot Trouble. A Pronated and Flat Foot.

At first sight there is little in common between the painful flat foot of young adults, *tarsalgie des adolescents* of Gosselin,[1] and the painless in-ankle of rickety infants, but the consideration of the mechanism in each case will render the essential relationship clear. Of course we do not mean that all the above-mentioned terms are synonymous. Doubtless some of them are, still we wish to imply that they are closely related manifestations due to a common cause.

General Considerations.—As we have stated on p. 667, the foot has a twofold function:—(1) Its use in active progression; (2) Its use as a passive support.

In active progression it is used as a lever, the toes being the fulcrum, the ankle-joint transmitting the weight, and the calf muscles attached to the heel being the chief force. In weight-bearing the stress is transmitted to the ground through a system of structural arches, not arches in the conventional architectural sense, but rather buttresses, held in position by muscular action, and prevented from spreading beyond a certain point by ties or braces composed of various ligamentous structures on the plantar aspect. They act rather as elastic or semi-elastic girders between the buttresses, supporting the weight transmitted through the tarsal and metatarsal bones.

[1] Cf. "La tarsalgie des adolescents," by D. Léon Thévenol, *Rev. d'orth.*, March 1905.

We must add a few words as to the so-called arches. The longitudinal outer arch, comprised by the os calcis, cuboid, and fourth and fifth metatarsals, is stronger than the inner. It rests almost flat on the ground, and its concavity is in most cases filled up with soft parts. It is well supported by ligaments, especially the strong calcaneo-cuboid, and the formation of that joint is such that the cuboid usually rests partly on the os calcis. Dane[1] has shown that this joint exhibits a considerable degree of variation. In a number of cases the articular surfaces are so nearly vertical as to afford no hindrance to collapse of the arch. Hoke[2] lays stress on the freedom from muscular support of this arch, as contrasted with the direct dependence on muscular activity of the inner longitudinal arch. The outer arch is therefore less liable to suffer from the effects of muscular fatigue. Its mobility as compared with the inner is smaller. It has only one bone, the cuboid, requiring support, and there is here no such mobile joint, suspended in a musculo-ligamentous sling, as the astragalo-scaphoid. The inner longitudinal arch is lifted nearly at its mid-point by the tibialis anticus muscle. The tibialis posticus braces it by keeping the scaphoid apposed to the head of the astragalus. Hoke and Bradford[3] dwell upon the effect of flexion and adduction of the first metatarsal bone in maintaining the arch; and Sampson[4] has also pointed out the importance of adduction of the great toe in supporting the arch and preventing it from rolling over inward and downward.

The posterior pillar of the inner longitudinal arch, formed by the os calcis, descends sharply from the highest point to the centre of the heel, thus showing that it is well adapted for weight-bearing, while the long anterior pillar slopes more gradually, is composed of several bones which are less strong, and as it is more elastic breaks the shock of impact. Whitman has emphasised the importance of the normal concavity of the inner edge of the foot. When weight is put on the foot it becomes less concave, and this is sometimes obliterated or even reversed, especially if the first metatarsal bone is not adducted. The convexity of the inner arch is directly associated with this concavity of the inner edge.

We have alluded on pp. 667-668 to the transverse arches, and their importance in flat foot and Morton's disease. Flattening of the posterior transverse arch is accompanied by valgoid rotation of the inner cuneiform, and the effect of this is to abduct the great toe.[5]

The movements of the normal foot have been detailed on p. 670. Particular attention should be paid to Whitman's views, that the range of adduction and of abduction of the foot is twice as great at the sub-astragaloid joint as at the medio-tarsal. The entire range of movement between extreme abduction and adduction is about 50°. Sampson[6]

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[1] *Trans. Amer. Orth. Assoc.* vol. xiii. [2] *Chicago Med. Jour.*, Sept. 1902.

[3] *Trans. Amer. Orth. Assoc.* vol. xiii. pp. 175-185.

[4] *Johns Hopkins Hospital Bull.*, Jan. 1902.

[5] Hoke and Bradford, *Trans. Am. Orth. Ass.* vol. xiii. p. 184. [6] *Loc. sup. cit.*

quotes Roberts,[1] who found that when the foot is in the adducted position the lateral angle of deflection is 31°, and in the abducted position it is 22°.

We have defined the movements of the foot somewhat briefly, as we wish to have some standard of measurement when we discuss disability. The actual nature of the movements will be rendered clear in dealing with the mechanism of pronation, to which we must now proceed.

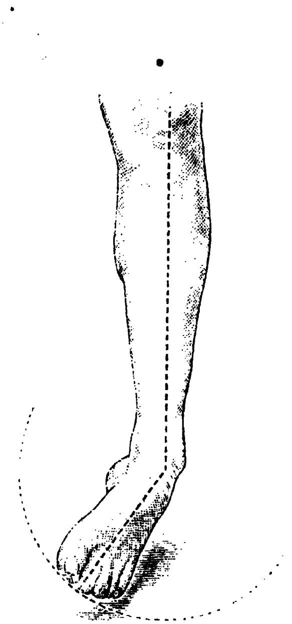


FIG. 507.—Voluntary Adduction.

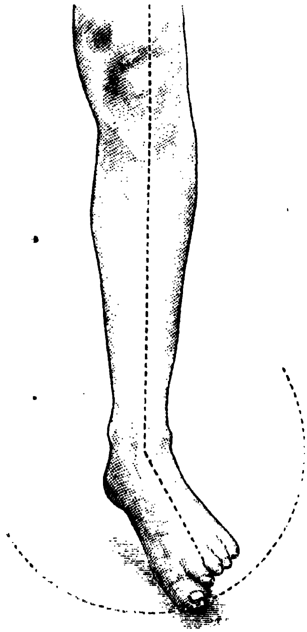


FIG. 508.—Voluntary Abduction.

In these postures the foot moves upon the astragalus, which is practically fixed between the malleoli. Adduction, the turning of the foot inward in its relation to the leg, is always accompanied by Elevation of its Inner and Depression of its Outer Border. This is known as Supination or Inversion of the Foot. The reverse of this attitude—Pronation or Eversion—is an accompaniment of Abduction, as is illustrated in the figures (Whitman).

Mechanism of Pronation.—Bradford and Lovett[2] remark: "When the whole weight of the body is thrown upon the limb, the foot being firmly planted upon the ground, the whole leg rotates inward at the hip. The inner malleolus moves downward, inward, and backward, the outer one forward.[3] The whole foot rolls over somewhat to the inner

[1] *Contributions to Orthopedic Surgery*, Philadelphia, 1898.

[2] *Orthopedic Surgery*, 3rd ed. p. 609.

[3] Many authors, however, state that the outer malleolus moves backward.

side. This is made possible, whilst the heel and front part of the foot are firmly supporting the leg, by movement at the medio-tarsal articulation. When the muscles and ligaments checking this position are weakened, the gliding at the medio-tarsal joint becomes exaggerated. Up to a certain limit this movement occurs in the normal foot. Beyond this limit it must be regarded as pathological."

"The abducted position, with eversion or pronation, is then one normally assumed when the body-weight is thrown on one foot or both, in such a manner that equilibrium is maintained without muscular exertion (Sampson), or, in other words, when the body-weight is balanced."

Shortly, then, abduction and eversion are physiological up to a certain point in weight-bearing, and beyond that are pathological. The big toe, by its natural tendency to become adducted, aids in supporting the inner longitudinal arch, and prevents the rolling over inwards of the pronated foot. The recognition of this point is of special importance in elucidating the connection between hallux valgus and flat foot. We also allude to this matter in discussing proper and improper methods of walking. In the strong walk of a healthy individual *the great toe is seen to be adducted when it is planted upon the ground.*

R. W. Lovett[1] says: "The position of the foot at rest, in the non-pronated foot, is assumed to be that where the line of the crest of the tibia, prolonged downward and forward, passes between the second and third toes, and where the inner border of the great toe, the internal malleolus, and the inner surface of the inner condyle of the femur, are all in the same vertical plane. But when weight is borne on one foot, so that the whole strain is thrown upon it, pronation takes place. This movement is most often noted in growing children." By direct observations and measurements, composite photographs, accurate plaster casts, a study of impressions of the soles of the feet, or better still, by direct observation of the same through a glass plate[2] aided by composite photographs, when pronation takes place, it can be shown that there is a marked inward movement at the ankle and a shuffling inward of the weight-bearing surface of the sole. At the same time the inner malleolus is seen to move downward and backward, and the outer forward. So that, in pronation, what takes place is abduction and eversion of the foot on the leg, some flattening of the longitudinal inner arch, and some obliteration of the concavity of the internal border. At the same time, the anterior transverse arch is flattened, and the heads of the second and third metatarsal bones come down to the ground, and the foot broadens. The bulging in and down of the scaphoid region on pronation can be well demonstrated by taking casts.

[1] *New York Med. Jour.*, June 20, 1896.

[2] The researches of Lovett and his colleagues on this subject are worthy of careful perusal, and a study of composite photographs (Fig. 516) is well repaid. Cf. Lovett, *New York Med. Jour.*, June 20, 1896; Lovett and Cotton, *Trans. Amer. Orth. Ass.* vol. xi.; Bradford and Lovett, *Orthopedic Surgery*, p. 608; Lovett, *Amer. Jour. of Orth. Surg.*, August 1903, p. 44.

We can now see that the persistence of this attitude of pronation explains the various types of weak foot before mentioned. And as Whitman emphatically says, "the mere condition of the inner longitudinal arch, although generally regarded as a characteristic feature

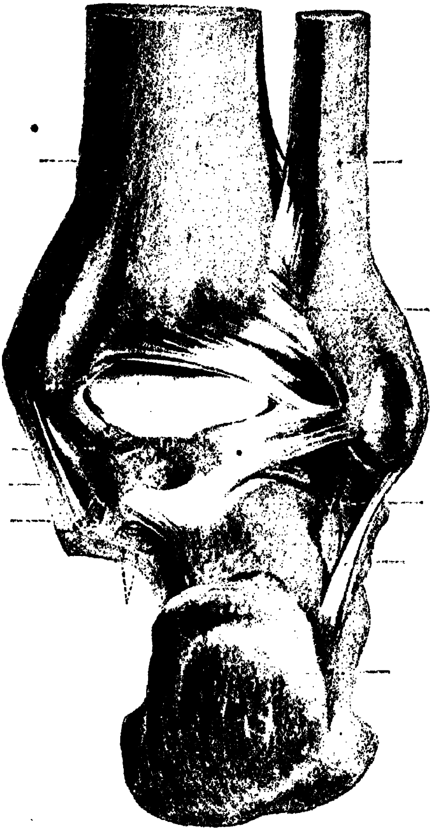


FIG. 509.—Posterior view of the Right Foot, showing the Ligaments and their Attachments. The weakness on the inner side is evident, and conduces to Pronation of the Foot in standing (Fick).

of flat foot, is really secondary to and less important than the alteration of the axis of the foot in regard to the axis of the leg." It is frequently insisted that in the pronated position the strain is taken off the muscles and thrown on the ligaments, and consequently it is often spoken of as "the attitude of rest." For our part we fail to see any such purposeful adaptation here, and regard it only as

a coincidence. Apart from the fact that this attitude is by no means similarly described by writers, all that we are disposed to say is that when weight is put on the foot it falls into the pronated position, which is just the position in which it is least able to cope with it (cf. Fig. 509). Hence the great frequency of static foot trouble, the "attitude of rest" becoming the "attitude of distress."[1] The tendency of the foot to topple over on the inner side is increased by abduction of the fore-part; but adduction, especially of the great toe, will counteract this tendency. Any cause, then, which favours abduction of the foot will enhance the natural instability and favour flat foot.

We may repeat that, under the collective term "flat foot," we include weak foot, weak ankles, splay foot, broken-down foot, and painful flat foot. In the words of Whitman,[2] "The deformity of the weak foot is an abnormal persistence or exaggeration of the attitude of abduction. The abduction is primary, the lowering of the arch is the secondary element. The symptoms are not due to the deformity as such, and have no proportionate relation to its degree. From the result of the over-strain and injury to which disordered function has exposed the foot, the changes in the muscles, ligaments, and bones that are found in cases of long standing are secondary and incidental to the abnormal functional use. They vary, of course, with the original structure of the foot, with the injury to which it has been subjected, and with the duration of the disability."

Predisposing Causes.—The predisposing causes are those which favour the position of abduction or of weakness or of pronation. These are—

1. The use of improper boots.
2. Walking with the toes turned out.
3. Standing with the feet turned out.

1. *Improper Boots and Stockings.*—The wearing of interchangeable pointed toe stockings, and practically of all other than specially constructed boots, gives rise to hallus valgus. We have already seen the great importance of free adduction of the great toe on the

[1] Engels, *Zeitschr. f. orth. Chir.* Bd. xii. Heft 3. We never stand completely at rest. There is always a play of muscles, now transferring the weight from the heel to the ball of the foot, now from the outer towards the inner edge of the sole, and now from one foot to the other. The position of rest alters with our varying occupations. In resting upon the sole, the os calcis represents only the posterior part of the two buttresses, transmitting its share of the burden to the ground.

[2] *New York Med. Record*, Aug. 31, 1907.

mechanism of the normal foot in walking. In the civilised adult, abduction of the great toe is always present. Lovett and Dane[1] state that this displacement of the great toe deprives the foot of its legitimate inside support, the support which should keep it from rolling over and pronating. Details as to proper boots will be found on pp. 671-673, 697, and 711.

2. *Walking with the Toes Turned Out.*—The proper walk is with the feet nearly parallel, with slight adduction of the first metatarsal

FIG. 510.—Illustrating the involuntary Adduction of the Fore-foot, due to the obliquity of the bearing surface of the metatarsus, in the proper attitude for Walking (Whitman).

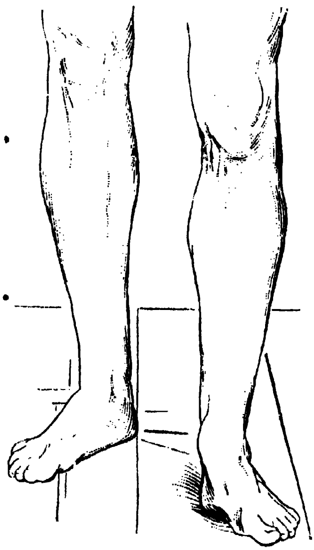


FIG. 511.—The improper attitude of Outward Rotation, in which there is disuse of the leverage function (Whitman).

bones and great toes (Figs. 510, 511). How great is the contrast afforded by the attitude in standing of the weedy office-boy and the bandy-legged tailor with the best types of physique in man, as exemplified by the art of the ancients or as compared with the mode of walking in savage races, and even with that of the shoeless street arab of to-day. They show that in walking naturally, the foot is placed with its long axis pointing almost directly to the front. The inner edge of the great toe, the inner malleolus and inner

[1] *New York Med. Jour.*, March 7, 1896.

condyle of the femur, are in the same plane, and the line of the crest of the tibia is prolonged downward, and passes off the dorsum of the foot at the cleft between the second and third toes. This position gives the maximum of strength, agility, and poise, with the minimum of fatigue, and the major portion of the body-weight falls on the outer arch.

It is true that walking is less likely to give rise to trouble than

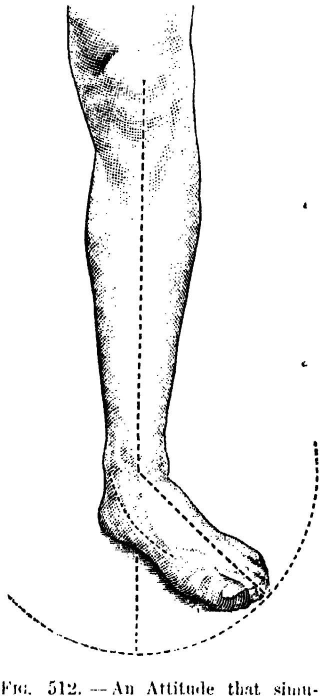


FIG. 512.—An Attitude that simulates the Flat Foot. An improper mode of standing (Whitman).

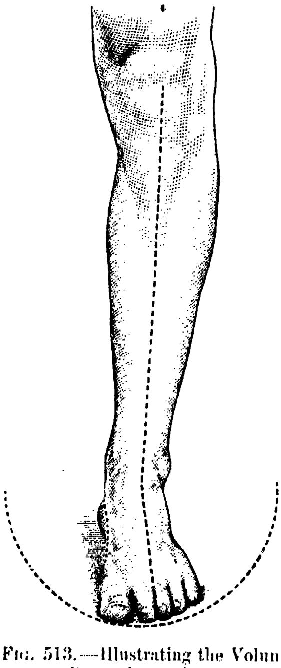


FIG. 513.—Illustrating the Voluntary Protection of the Foot from Over-strain. The proper mode of standing (Whitman).

prolonged standing, as the position is constantly varied. Still, walking with the toes turned out is a very potent factor in producing deformity. It accounts for a great deal of foot trouble amongst soldiers. In 1898 the Secretary of State for War had his attention called to the number of men invalided from the Army on account of flat foot.[1] It is difficult to account for the adoption of such an erroneous attitude as that of walking with the feet out. It has,

[1] *Lancet*, April 23, 1898, p. 1427.

however, long been the first position of the dancing-master and gymnastic instructor, and finds its extreme expression in the absurd German parade- or goose-step.

3. *Standing with the Feet Abducted.*—As the muscles tire with prolonged standing, the strain is more and more thrown on the ligaments of the lower extremities. Hence the "attitude of rest," with the thighs rotated in, the knees touching, the tibiæ rotated out, and the feet abducted, a position which throws strain on the internal

FIG. 514.—A severely Pronated and Flat Foot.

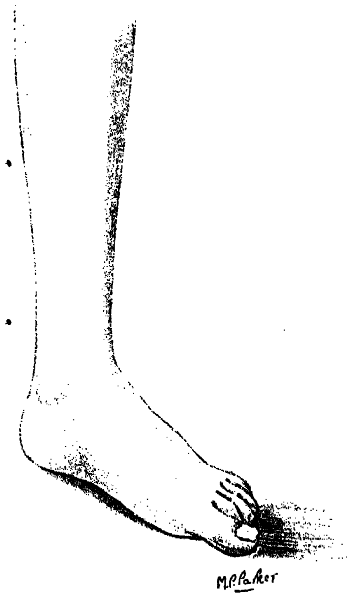


FIG. 515.—The same Case as in Fig. 514, after Treatment by Wrenching, Manipulation, Retention in Plaster of Paris, followed by Exercises and the use of Supports.

lateral ligaments of the knees and the ligaments of the inner longitudinal arches of the foot. We know that abduction is always associated with eversion or pronation. When weight is borne upon the feet, the astragalus rotates downward and inward upon the os calcis, depressing its anterior and internal border until the movement is checked by the calcaneo-scaphoid and deltoid ligaments. In a position of rest, and particularly in a weak and flat foot, the leg has a tendency to slip downward and inward from off the foot (Fig. 514).

Bad postures, then, are predisposing causes, and as we have shown how frequent such causes are, static flat foot should be a very common condition, and it is so.

Frequency.—Flat foot is the most frequent of all deformities. It forms two-fifths of all orthopædic cases.[1] According to Hoffa flat foot forms 53·41 per cent of all deformities. And if we add to those seen in Orthopædic Clinics the large number of patients who worry the shoemaker, and do not apply for surgical treatment, it is evident that it is a very frequent condition indeed.

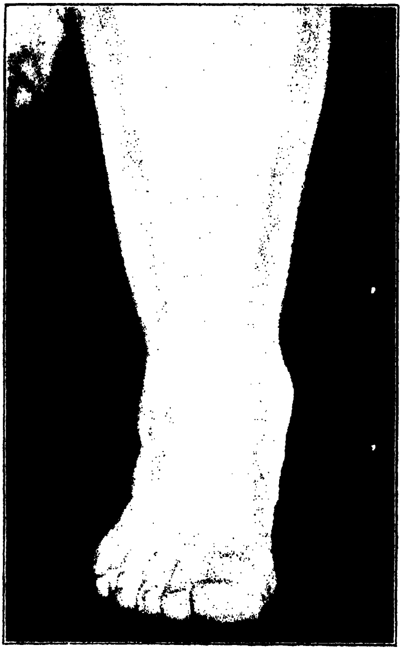


FIG. 516.—A Composite Photograph, showing the Lateral Excursion of the lower part of the leg and of the foot, with and without Superincumbent Weight (Dane).

Age. — From the fourteenth to the twentieth year is the usual period of onset, the reason being that during that time the feet are first put to the test of occupation-strain.

Sex.—It is more prevalent in females than in males, in the proportion of 67 to 42.

Intrinsic Causes. — If we sum up all that has gone before we shall see that there are four conditions which are responsible for static foot trouble :—

1. Those in which the support is deficient. Such are congenital or acquired abnormality or weakness of structure.
2. Where power is insufficient, such as weakness of muscles.
3. Where the burden is too great; here over-strain and over-weight are the factors.
4. Where the adjustment is imperfect, that is, where improper attitudes are adopted that subject the foot to a mechanical disadvantage in the performance of its functions.

[1] W. E. Blodgett, *Amer. Journ. of Orth. Surg.*, 1904.

These causes cannot be separated from one another. They are often interdependent.

In discussing them we may take them in order.

Excessive weight-bearing may produce its effects in both strong and weak individuals (cf. Fig. 516). Flat foot is seen in professional strong men and jumpers. It is also seen in weedy youths who commence life as errand boys (Fig. 506). In middle life, when the figure becomes rotund and the muscles soft, the feet are abducted and the arches give way.

Deficiency of muscle is seen in those who are convalescing from an acute illness, or who are chronically in poor health. The muscular debility of rickets is frequently associated with weak foot, and the valgus of infantile paralysis is often obvious.

Deficiency of support, due to weakness of structures, is exemplified by weak ligaments, such as, for example, the lax ligaments in rickets, and the loss of tension associated with sprains, traumatisms, especially Pott's fracture, rheumatism, gout, arthritis deformans, neurasthenia, and anaemia. In certain subjects, with long, narrow feet, the ligaments are naturally lax, and it is this class of case which so frequently shows the partial dislocation inwards of the scaphoid and the painful prominence over it.

Amongst intrinsic causes we must also mention locomotor ataxy and an intractable type of flat foot seen in young adults, accompanied by muscular atrophy. Lastly, in cases of short leg, when the weight is borne more on one foot than the other, one foot frequently becomes weak.

Symptoms.—These are: (1) Pain, (2) Tenderness, (3) Swelling, (4) Disability, (5) Deformity. As we shall see in discussing the types, symptoms are very variable, and one or even two may be absent.

1. *Pain, its Occurrence and Position.*—Blodgett analysed 1000 cases of static foot trouble in patients over twelve years of age. He found that 3·8 per cent were painless, in 68·1 per cent pain was in the feet only, in 25·9 per cent pain was in the feet and lower limbs, and in 2·2 per cent there was no pain in the feet, but in the legs only; that is, in more than 95 per cent of the cases pain was the leading symptom. Of the few painless cases more than half were under twenty years of age; although of the whole 1000 cases analysed only 170 were under twenty years of age. The pain was localised most frequently about the astragalo-scaphoid joint, then about the heads of the metatarsal bones, some-

times in the plantar surface and the centre of the heel, and sometimes it spread over the sole of the foot generally. In the minority of cases it was found between the external malleolus and the cuboid, and in a few cases on the plantar surface of the head of the first metatarsal bone. Above the ankles, the frequency of pain was greater in the calf than in the knee, and more in the knee than in the back.

The Character of the Pain.—The pain bears no constant ratio to the amount of deformity. Severe flat feet may present no painful symptoms, and the feet may be quite useful. It is well known that some excellent sprinters are flat-footed. It is not uncommon, also, to find that when both feet are affected the subjective symptoms are more prominent in the less deformed foot. Further, in many cases coming for treatment the symptoms may be of short duration—not more than a week or so—and yet it is obvious that the deformity has been developing for a year or two. Occasionally, however, pain is the first sign and precedes deformity.

Probably these differences are explained by the rate of change in the relationship of the parts. Thus the deformity may be very slowly progressive and allow time for painless adaptation. The reverse may occur and acute straining of ligaments ensue. This explains why the individual in whose foot the arch is well formed and the ligaments presumably sound, suffers from the symptoms of strain long before the arches have been depressed or deformity is apparent. In those cases where the pain is greatest in the morning on rising, the explanation is, doubtless, that during rest there is a partial reposition of the displaced bones, which are again forced into the deformed position on standing.

Occasionally the pain is only complained of after a twist or sprain of the foot. It then appears that although the ligaments and muscles were relaxed previously to the injury, and some valgus was present, yet the strain has been sufficient to cause sudden giving way from softening of the weakened ligaments, and then all the causes of pain come into action.

The character of the pain is not uniform. In the early stages there is at first a feeling of fatigue, succeeded after a few days or weeks by a dull aching, which is noticed first in the feet, and then extends to the legs and thighs. On resting with the feet raised, the aching passes away, but day by day the pain comes on earlier, lasts longer, and is more acute.

2. *Tenderness.*—The point most usually tender is the centre of the heel, and next to that the astragalo-scaphoid joint, then the sole of the foot, and lastly beneath the head of the first metatarsal bone.

3. *Swelling of the Feet.*—Local puffiness is frequently seen, and occasionally redness, dependent on the amount of standing and walking. In old-standing cases œdema of the feet occurs.

Sweating of the feet is very frequent. In some cases the parts are hot, and in others cold and clammy, thus pointing to vaso-motor disturbance. The frequent co-existence of varicose veins in adults is very noticeable. Indeed, in some such cases it is probable that the defective circulation, as exemplified by the dilated veins, is a cause of muscular and ligamentous relaxation, and therefore predisposes to flat foot.

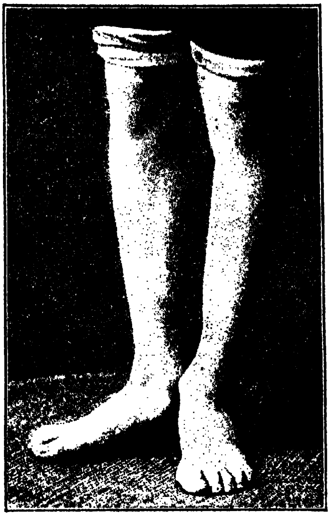


FIG. 5 Weak Feet, Arches not Depressed. The feet are also Pronated (Whitman).

4. *Disability.* — Besides the lameness due to pain and tenderness, there is disability arising from loss of mobility. In the majority of cases inversion and adduction are restricted; in some cases the power of dorsiflexion is partially lost. In other cases, particularly the spasmodic type, the movements of the foot are generally limited. The gait is clumsy, inelastic, and the patient plants his heels forcibly on the ground.

5. *Deformity.*—On reviewing what has already been said, and noting the description of types to be mentioned shortly, it is hoped that a sufficiently clear picture will be formed. We may say that all "weak feet" are abducted feet, all flat feet are abducted feet, but all abducted feet are not flat feet. We therefore distinguish three classes, and we have placed them in the order in which deformity becomes marked.

1. The abducted foot, in which the arch is well formed.
2. The abducted and flat foot, in which the arch is lowered.
3. The flat and abducted foot, in which the foot is flat and the arch entirely lost.

We may amplify and proceed to the discussion of—

Types.—These vary widely, according to the amount of pronation, condition of the arches, degrees of disability, rigidity, and muscular spasm.

1. *The Pronated Foot, with little breaking down of the Arch.*—This is a very common type, and occurs most often in the massive feet of full-grown adults. There is not much rotation outward of

FIG. 518.

FIG. 519.

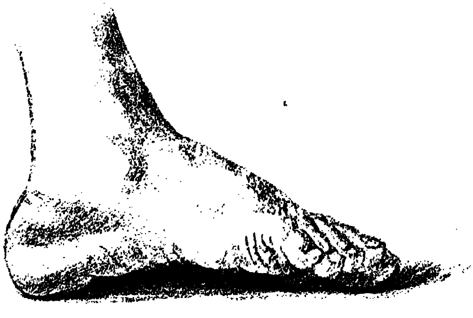


FIG. 520.

Three views of a Spasmodic Pronated Foot, with Rigidity of the Peronei and Extensor Communis Digitorum Tendons.

the foot in front of the astragalus when the patient is standing (Fig. 517, and cf. Fig. 516). When the patient is not bearing his weight on the foot the longitudinal arch is normal or only slightly flattened, and during weight-bearing the arch is never entirely lost. This type of pronated foot should be kept separate, clinically, from ordinary flat foot. It sometimes becomes spasmodically everted (Figs. 518, 519, 520).

2. *A Type frequently seen in Slender Feet,* with decided abduction of the fore-foot and an arch unusually high, even during weight-bearing.

FIG. 521.

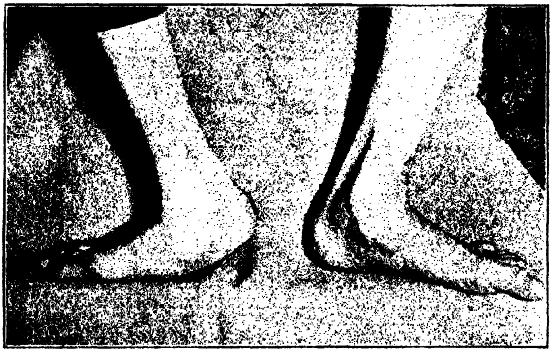


FIG. 522.

Two views of a case of severe Spasmodic Pronated Feet. In Fig. 521 the feet are off the floor; in Fig. 522 the patient is standing.

3. *The Thoroughly Flat Foot, with Prominence of the Scaphoid* (cf. Fig. 506, p. 675).—In its moderate form the flat foot can be replaced. In its extreme form the foot resists passive movements;

it is abducted and everted, with spasm of the peronei and extensor communis digitorum. In fact it is the "rigid and spasmodic flat foot" (Figs. 521, 522). Much of the spasm disappears under an anaesthetic, and reappears when the patient recovers consciousness. As to the reason of the peronei and extensor communis digitorum undergoing spasmodic contraction a suggestion has been made by Whitman. He says it depends upon the irritable condition of the overworked and contracted abductor muscles, practically the only group which retains functional power.

4. *Flattening of the Arch of the Relaxed Foot in Weight-bearing without Commensurate Pronation*, that is, abduction and eversion due apparently to direct depression. This the author designates the "flabby flat foot" type.

FIG. 523.—Rickety Flat Feet (Bradford and Lovett).

5. *The Abducted Foot*, in which the arch is so high as to constitute a condition of pes cavus, and it is found that the tendo Achillis is contracted. This condition is fully described on p. 320 under the title of "right-angled contraction of the tendo Achillis."

6. *The Weak Ankle Type of Childhood*, in which eversion takes place chiefly at the ankle-joint, so that when the foot is in use it is in a position of valgus. It is often so in rickets (Fig. 523).

In childhood, curved tibiae are at first accompanied by slight inversion of the feet; later on this yields to a compensatory valgus. In children also, with slight knock-knee, the feet are everted; in adult life knock-knee is often, but not always, accompanied by inversion.

7. *Exceptional Types of Flat Foot.*—Instead of the bulging on the inner side being in the immediate vicinity of the medio-tarsal joint, the internal cuneiform is displaced downwards and inwards (see Figs. 524, 525); and another irregular form is *hallux flexus*, with depression of the arch.

The Condition of the Anterior Arch of the Foot.—It is

found that in nearly all cases of flat foot, using the term in its broadest sense, the anterior arch is flattened to some extent and painful; and the pain almost always centres about the head of the fourth metatarsal bone, giving rise to symptoms more or less characteristic of Morton's disease.

FIG. 524.—An unusual variety of Flat Foot. The maximum prominence on the inner side of the foot is at the internal cuneiform bone and not at the head of the astragalus.

Pathology and Morbid Anatomy.—There is little to be added to what has already been said under mechanism and causation. Gosselin[1] has studied the question exhaustively, and found at the post-mortem examination of a young woman congestive lesions of the articular cartilages and ligaments, and he considered the condition arthropathic. Later, Le Roux confirmed Gosselin's findings at

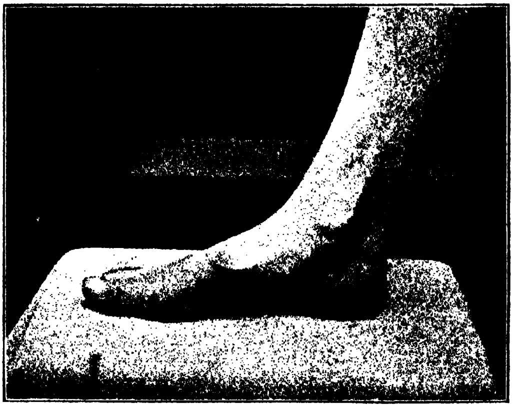


FIG. 525.—Inner view of same foot as in Fig. 524.

other examinations. Nevertheless such conditions are doubtless secondary.

[1] Quoted by Cabot, "De la tarsalgie douloureuse des adolescents." Thèse de Paris, 1866.

Sayre noted weakness of the tibialis anticus muscle, and the present writer has observed wasting of that structure (see Fig. 526). And Dittel[1] has seen it in a state of fatty degeneration. But probably these cases were on the borderland of paralytic and static cases. Henke found general muscular feebleness, especially of the tibialis anticus. Duchenne advanced the view that the peroneus longus was the muscle chiefly at fault; most surgeons find this structure to be in a state of overaction and often of spasm.

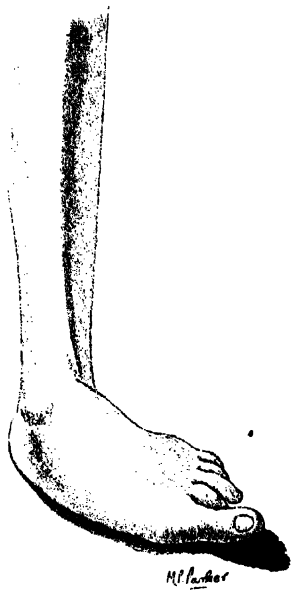


FIG. 526.—A very Severe Type of Static Flat Foot. Note the groove externally to the crest of the tibia and due to the wasting of the Tibialis Anticus.

In flat foot the spasm is reflex in character; and, as we shall see under treatment, the injection of a solution of cocaine into the astragalo-scaphoid joint causes subsidence of the spasm. Apart, however, from general muscular weakness, except in a few cases, the pathogenesis of the condition is other than muscular. Muscular changes are late in appearing, and are secondary to partial loss of mobility and function of the parts.

As to the osseous and ligamentous conditions, it is evident from what has been said that these do not require the minute descriptions sometimes given to them. Firstly, because they are to be regarded as effects rather than causes; secondly, because they are a matter of degree, and no one description applies to the various types; and, thirdly, because many of the conditions mentioned, such as changes of the arthritis deformans type, are coincidental rather than essential.

In the typical rigid and painful flat foot, abrupt deviation outward takes place at the transverse tarsal joint. The scaphoid is partly dislocated from the head of the astragalus, the head of which is rotated downward and inward, and forms the usual prominence on the inner border of the foot. The os calcis is rotated, so that its inner surface looks downward and inward, and its outer surface in the reverse directions. Much of this

[1] Kirmisson, *Difformités acquises*, p. 477.

rotation is found in the subastragaloid joint. As the arch sinks, the scaphoid and the astragalus approximate to the ground until they finally touch it (Fig. 527). The cuboid is pressed against the os calcis above, and may even become ankylosed, but the calcaneo-cuboid joint is widened below, and the os calcis may be so everted that a new joint forms between it and the fibula.

The relations of all the bones of the foot are more or less altered, partly by sliding and partly by rotation. Hoffa[1] and Nasse invoke softness of bone as a cause. Observations, however, do not substantiate their views; Wolff has shown that no such softening is needed to explain bony transformation in flat foot.

Changes in the ligaments proceed *pari passu* with alterations in the relations of the bones. In some directions the ligaments are elongated and thinned, and relaxed; in other directions the reverse obtains. Considerable attention has been directed to the inferior calcaneo-scaphoid ligament, and it is generally stated that this is elongated. And it is a difficult point to decide, since the measurements of the ligaments ought to be made in the same foot both before and after the deformity. Some observers think that the differences between the feet in childhood and adults are accounted for by the effect of weight in inducing pronation. They state that the arch is lacking at birth, and only develops under the stimulus of muscular action; yet Dane[2] has conclusively shown that the arch at birth is perfectly formed, but owing to the pad of fat in its hollow, impressions give an erroneous idea of flatness of the foot. Pes planus is therefore no longer explicable on the ground of failure of development of the arch. The condition must be relegated to the acquired painless infantile form. Certain races suffer more frequently from flat foot than others, particularly the Semitic and the semi-civilised American negro. In the latter it is the outcome of wearing the white man's shoe.

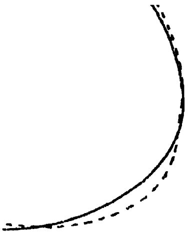


FIG. 527.—Tracing of the Inner Side of the "Arch" of the Foot. The dotted line indicates the outline when weight is borne upon the foot, the continuous line when weight is removed. The tracing is taken about the scaphoid bone, and shows its excursion in weight-bearing.

From the preceding remarks it is evident that the division of flat foot into degrees is not reasonable. The term flat foot being used in its most comprehensive form, embraces a great number of

[1] Langenbeck's *Arch.*, 1895, vol. i. p. 40.

[2] *Loc. sup. cit.*

clinical conditions, all of which have a common pathogeny. All tend ultimately, if left untreated, to drift into the troublesome, rigid, spasmodic, and painful foot, or the very hopeless form of so-called osseous flat foot, in which partial ankylosis has taken place in various joints.

The pathology of spurious valgus is much assisted by a consideration of Von Meyer's triangle (Fig. 528). If the patient is standing firmly on both feet, a triangle may be drawn by uniting three points, the centre of the heel and the heads of the first and fifth metatarsal bones. In a normal foot the triangle is acute inwards, with its apex at the heel, and the centre of the trochlear surface of the astragalus (the "astragalus point") is immediately above the inner line of the triangle. In a flat foot the "astragalus point" is gradually displaced more and more internally (Fig. 529). The inner line of the triangle is also increased, and the outer side shortened. The measurements of a flat foot show that the actual length of the inner border is increased and that of the outer is decreased; and, further, the mid-point of the normal foot is displaced more forward in the flat foot.

Prognosis.—Flat foot cannot be cured without treatment. The pain and disability become steadily worse, and the patient has to seek relief. Occasionally, however, after several years, when the breaking down of the arch has ceased, the pain disappears, but the foot is permanently damaged, and has lost nearly all its usefulness. Weak foot and flat foot readily yield to treatment by simple measures, and excellent results can be obtained in the rigid form by operative measures.

Diagnosis.—There is probably no condition so easily and often overlooked as acquired valgus. If we refer to the account on p. 685 of the unusual distribution of pain and tenderness, we can understand that this is so; and mistakes are usually the result of carelessness. The feet should be carefully examined when at rest, on standing and in walking. The range of movement is to be carefully noted and the strength of the muscles tested, especially in the directions of adduction and inversion or supination. Impressions of the feet should be taken, either by covering the soles with printer's ink or with lamp-black, or the glass table described by Bradford and Lovett[1] is useful.

Differential Diagnosis.—Pains in the feet are often ascribed to rheumatism, especially as it occurs sometimes in the back of

[1] *Orthopedic Surgery*, 3rd edit. p. 568.

the legs in flat foot. It is commonly thought that unless the arch

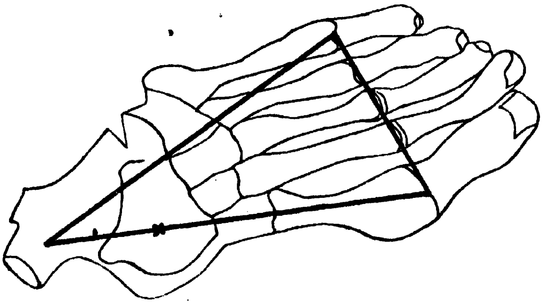


FIG. 528.—Von Meyer's Triangle in the Normal Foot. The "Astragalus Point" is immediately above the inner side of the triangle.

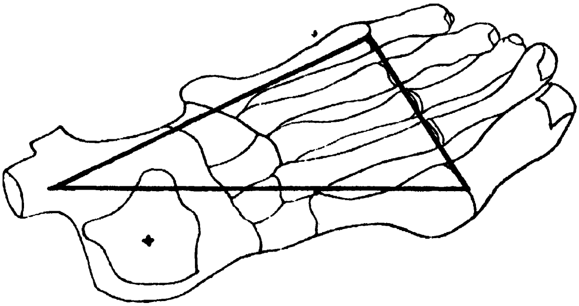


FIG. 529.—Flat Foot and Von Meyer's Triangle. The "Astragalus Point" (+) lies entirely inside the triangle.

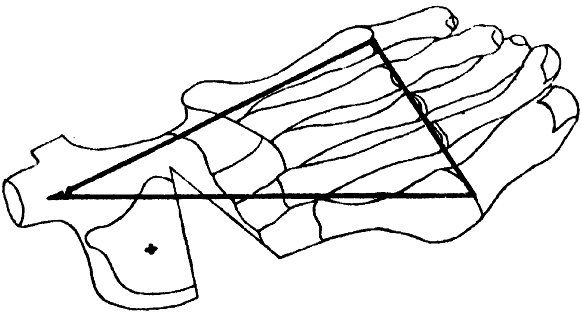
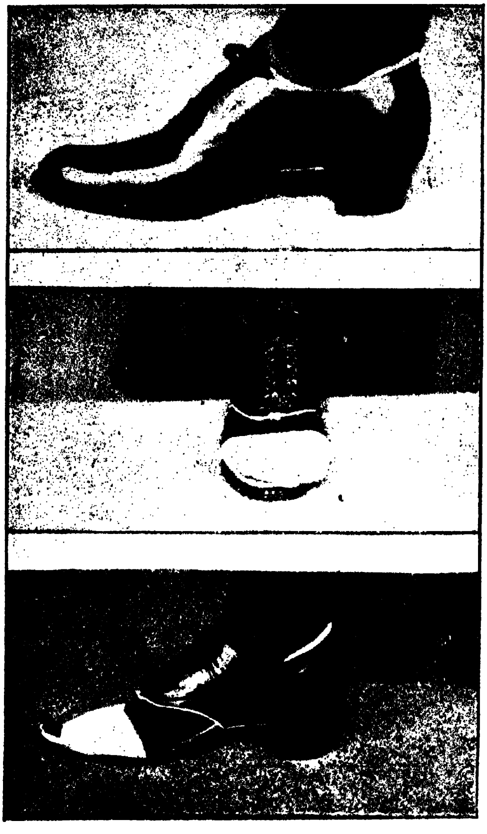


FIG. 530.—Flat Foot and Von Meyer's Triangle. The Foot after Removal of a Wedge-shaped Portion of Bone. Sir William Stokes' Operation for Flat Foot, viz. Removal of a Wedge from the Head and Neck of the Astragalus, is followed by Adduction of the Foot, and places the Astragalus Point (+) immediately above the inner side of the triangle.

of the foot is fallen there is no static trouble in the feet. Still it is quite certain that even when no dropping of the arch of the foot

can be detected by the eye, it is most unwise to make a lightning diagnosis of rheumatism. Changes in the shape and outline of the bones of the foot and abnormal joint conditions are frequently ascribed to arthritis deformans. More often, however, these changes are due, not to this disease, but to alterations in the static relationships of the parts.



FIGS. 531, 532, 533.

Three figures showing the effect of the shoe in constricting the front part of the foot. In Figs. 532 and 533 the upper of the shoe has been cut away to show how much the foot is squeezed by the shoe (Bradford and Lovett).

When tuberculous osteitis of the astragalus or scaphoid is present, with thickening of the periosteum and soft tissues in the concavity of the arch, the appearances may be similar to those in flat foot.[1] Such cases must be carefully investigated and watched, otherwise mistakes are easily made. In fact, any cause which obliterates the posterior arch may lead a careless observer into error. The rare condition of painful lipoma of the feet (p. 371), described by the author, was brought under his notice by a patient who had been told that she was suffering from spurious valgus.

Treatment. — The conditions and surroundings should be

[1] Cf. Poncet, *Ann. méd. chir. du centre*, Jan. 1, 1905; Thévenot and Gauthier, "Tarsalgie des adultes d'origine tuberculeuse," *Revue d'orth.*, Jan. 1, 1905; Martin Thèse de Lyon, 1904 and 1905.

noted. Anæmic patients require iron, and rickety children cod-liver oil, plenty of fresh milk, and pure air. Overworked folk should rest, and change of occupation is usually required.

Locally, the principles of treatment are comparatively simple. They consist of avoiding those habits in walking and standing which favour the abducted and pronated positions of the foot, with the use of proper foot-gear as a preventative measure. Support of the foot in the proper position, and the development of weak muscles by means of massage and exercises, are the lines along which treatment should run. Rigid and fixed flat feet require correction by mechanical and operative measures. In all cases, where pain is a prominent feature, local rest, with the feet adducted and inverted, is a necessary preliminary.

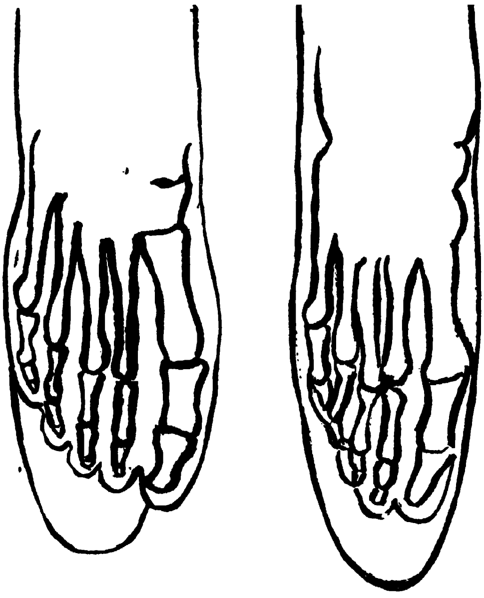


FIG. 534. FIG. 535.

Tracing of Skiagram of Foot in Shoe before and after Removal of the "Upper" (Bradford and Lovett).

Sufficient has been said on p. 677 as to proper and improper methods of standing and walking, and there is no doubt that one of the best exercises for the cure of flat feet is correct walking.

Proper Foot-Gear.[1]—The essential point is that the feet should be maintained, or at least permitted to assume in walking, the position of greatest strength, namely, adduction.

"The forces which give rise to adduction of the foot come into play mainly at three points: on the inside, opposite the medio-tarsal joint; on the outside, opposite the head of the fifth metatarsal bone, and on the

[1] Cf. also pp. 671, 711.

outer point of the heel. When the foot is adducted the outer border is convex, and the boot must be made so, or at all events not concave. The depth of the upper must be greatest over the big toe in front, to allow it free play. The width is to be at least that of the weight-bearing portion of the foot when it is firmly planted on the ground. At the back the boot is firm, and not stiffened beyond the medio-tarsal joint. It should be snug over the instep, so as to prevent wrinkles, and the heel low and broad. The forward part of the sole is to be flat, and not convex downwards, so that the toes may finish the step in walking, and this part of the sole also is flat, and not convex, from side to side. The front part of the inner edge of the side of the boot curves inward so as to permit adduction of the great toe, and the depth of the upper over the toes gives ample play to them; in fact, boots should always be 'blocked' high here. Unhappily the dictates of fashion override the teaching of common-sense, and there are few people who can be induced to wear boots constructed so as to give full physiological

FIG. 536. – A Shoe arranged so as to avoid Pressure on the Dorsum and prevent the usual Cramping Distortions of the Foot (Bradford and Lovett).

play to the feet in walking. It is advisable also not to have interchangeable socks or stockings, but each made to fit the foot; and it is an excellent plan to have them made with a separate space for the great toe."

Curative Measures.—In moderate cases, and in the after-treatment of the severer cases, rest is essential to relieve pain and spasm, and the feet may be kept in the varus position by applying malleable iron splints on the outer sides. The nutrition of the parts can be improved by soaking the feet in hot water for five minutes, and then douching with cold water. When the pain and spasm have passed away exercises are valuable, and we must repeat that no exercise is so satisfactory as correct walking. The patient should sedulously practise inverting movements of the soles, and

particularly adduction of the great toes. He should also walk on the outer edge of each foot with the sole inverted. When the nutrition of the muscles is improved, tiptoe exercises with the feet well to the front and the great toes adducted are carried out, but this form of exercise must not be undertaken at first in the weak, broken-down foot. Another excellent exercise is the following:—

The limb being extended, with the patella to the front, the foot is first plantar-flexed, then turned inward and adducted, then inverted, and finally dorsiflexed to the full limit. The last movement is important. This exercise may be carried out at first sitting, and then standing.

Whenever the patient is sitting he ought to invert the feet, and allow the weight to fall on the outer borders. In order to strengthen the supinators, that is, the inversion muscles, Hovorka[1] makes the patient walk to and fro on his supination board, made of two smooth boards, joined at their long edges at an angle of 164° to 165,° and covered with felt. Brunella advocates cycling, with the pedals made thicker internally. The tibiales and adductors may be strengthened by suitable resistance exercisers, and my colleague, Mr. Muirhead Little,[2] has called attention to this method of treating orthopædic cases. All are agreed that passive movements and massage are of the greatest importance.

We now pass on to the consideration of boots, pads, plates, and other forms of support.

Apparatus for Flat Foot

The Thomas shoe or boot (Fig. 537), with the oblique heel and valgus wedges, is in universal use. The valgus wedge is an arrangement by which the inner edge of the sole is made thicker than the outer. The difference may be an eighth to a quarter of an inch. A valuable point is that the upper surface of the sole and heel should be flat and not concave. The principle of the Thomas boot is essentially sound. The physiological fact that inversion of the foot is accompanied by raising of the arch is recognised, and is made use of. Some surgeons think that these boots cause the feet to slide down externally, so that pressure comes on the outer border and causes corns; but experience shows that this is seldom the case.

Use of Surgical Apparatus, meaning thereby the carrying of irons up the outside of the leg, and the employment of a T-strap. Now that we more fully understand the pathogeny of flat foot, we recognise that it

[1] *Zeitschr. f. orth. Chir.* Band xii. Heft 3.

[2] *Lancet*, April 6, 1901.

is not so much the prevention of fall of the arch as the free muscular play of the foot in a normal physiological direction that is wanted. An outside steel support fixed into the boot cramps and confines the foot in its movements, and therefore has been rightly discarded by many surgeons.

Supports to the Arch.—Pads of cork, vulcanite, and leather sewn into the sole of the boot answer fairly well considering their inaccuracy. But they frequently cause pain from pressure at first and wasting of the tissues of the sole. Further,

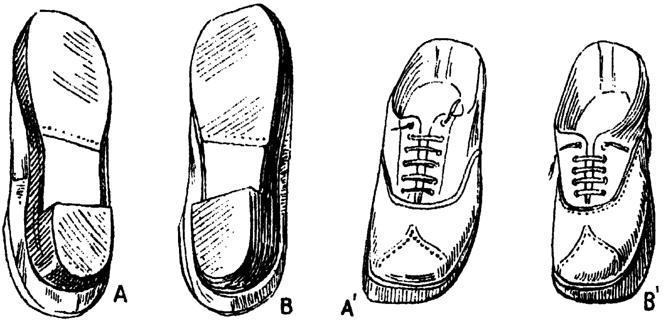


Fig. 537.—A, A', Under and Upper Views of a Shoe with the Inner Edge of the Sole and Heel thickened (a Valgus Wedge), so as to cause Inversion in Flat Foot. B, B', Under and Upper Views of a Shoe with the Outer Edge of the Sole and Heel thickened (a Varus Wedge), so as to Evert the Foot.

they do not take into account the fact that in flat foot the anterior and posterior transverse arches are spread, and this they cannot prevent.

Metal Sole-Plates.—A very inefficient form is in common use, consisting of a square piece of metal hammered out so as to fit the inner

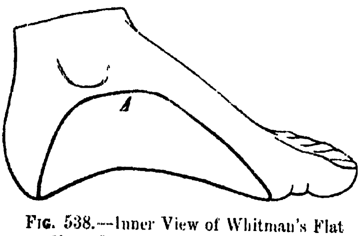


Fig. 538.—Inner View of Whitman's Flat Foot Brace (Valgus Plate). A, The Astragalo-Scaphoid Articulation.

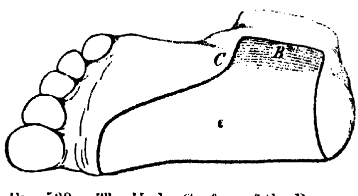


Fig. 539.—The Under Surface of the Brace and the Outer Flange. B, the Calcaneo-Cuboid Articulation; C, the posterior extremity of the Fifth Metatarsal Bone.

longitudinal arch, and held in position by means of elastic material passing over the dorsum. This has all the defects of a fixed pad, and none of the advantages, and should never be used.

Valgus Plates.—The best known, and on the whole the most efficient, are the Whitman valgus plates (Figs. 538, 539). They are suit-

able for those cases in which the foot is still flexible, and can be replaced passively. They are particularly useful for the flabby flat foot, and for those in which there are no bony prominences on the inner margin. When the scaphoid is partially dislocated, the inner edge of the plate may rub against it and causes pain. The plate should never be used when rigidity is present, as the foot cannot adapt itself to the support. The deformity is first reduced and the foot made flexible, and then the plate can be used.

Whitman[1] gives the following directions for the manufacture of his valgus plate:—

"The patient is seated in a chair opposite another chair, somewhat

FIG. 540.—Modelling a Whitman's Brace (Valgus Plate) for Flat Foot. The Position of the Foot before the Plaster Mould is taken. The Foot rests on its Outer Border on the Inclined Surface (Whitman).

less in height, on which is laid a thick pad of cotton wool, covered with a square of cotton cloth. Then plaster of Paris is added to water until a mixture of the consistency of thick cream is obtained. The patient's knee is now flexed, and the outer side of the foot, previously rubbed with talc powder, is allowed to sink into the plaster which has been poured upon the cloth. The foot should be slightly plantar flexed, and its transverse measurement should be perpendicular to the chair. It is an advantage to lift the foot, and to have the surface of the second chair so inclined that the highest side is towards the front of the foot (Fig. 540). This, together with the weight of the limb, will assure slight adduction. The borders of the cloth are raised, and the plaster is

[1] *New York Med. Rec.*, Aug. 31, 1907, p. 343.

pressed against the foot until rather more than half is covered (Figs. 541, 542). As soon as the plaster is hard, it is removed, its upper surface

FIG. 541.—The Lower Half of the Mould (Whitman).

coated with vaseline, and it is temporarily replaced. The remainder of the foot is then covered with plaster. The two halves are then removed

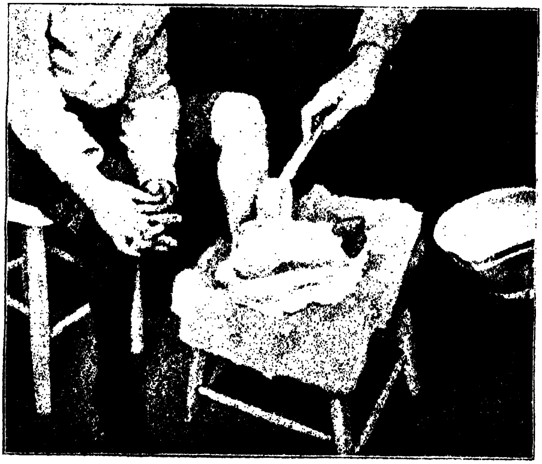


FIG. 542.—The Upper Half of the Mould (Whitman).

(Fig. 543), again greased and bandaged together. The interior is damped with soap-suds, and it is then filled with plaster cream. On removing the shell a cast of the foot (Fig. 544) is seen, which, when properly

made, should stand upright without inclination to one side or the other.

"In most instances it will be an advantage to deepen in the plaster

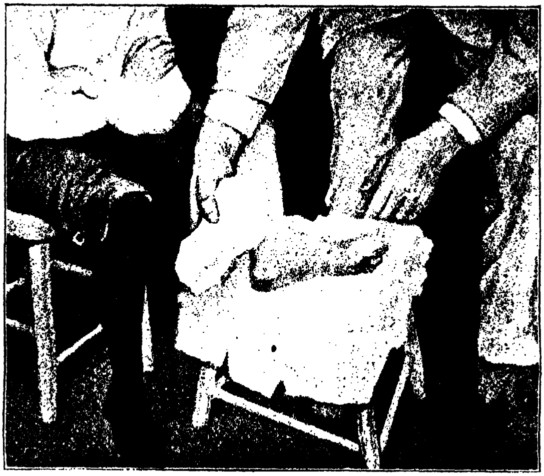


FIG. 543.—Separating the two Sections of the Mould (Whitman).

model the inner and outer segments of the arch, in order that the arch of the brace or plate may be slightly exaggerated, especially at the heel, so

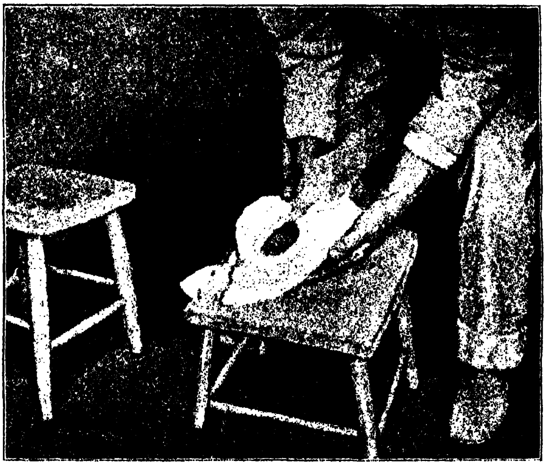


FIG. 544.—The Mould ready for the Casting (Whitman).

that the depression of the anterior extremity of the os calcis may be prevented. If the outer border of the cast is flattened by pressure, a

little plaster should be added to approximate to the normal contour. If there is prominence of the scaphoid or head of the astragalus on the inner side, the plaster should be thickened in the model over these points, so that there is very slight, if any, pressure upon them when the brace is completed.

"**Construction of the Brace or Plate.**—The outline is drawn as illustrated in the diagrams 538, 539. Whitman uses best sheet-steel, 18 to 20 gauge, but in England we prefer aluminium bronze, as it is less likely to rust. Whichever material is used, the sheet, cut after the pattern, is moulded on the plaster cast. The most common error of those who use the proper shape is the making the plaster mould with the foot in the upright position. A cast made in this manner is from one quarter to one half an inch wider than when the foot is placed upon the side. A brace made on such a defective model is rather a comfortable support than one which not only restrains deformity, but also enforces an attitude in which cultivation of muscular ability can hardly be avoided."

The last sentence expresses exactly the superiority of Whitman's brace over all other kinds of support for flat foot. It supports the foot, and does not restrain its normal movements. In fact it increases their range.

Before the patient walks, the inner edge of the sole and heel of the boot should be thickened. The result is that when he throws his weight on the outer side of the foot the external part of the brace is pressed down, and the internal flange is lifted towards the inner side of the foot. It is instinctively drawn away from the pressure, and thus towards the normal contour. He cannot turn the foot outwards in walking because this causes discomfort. He is therefore compelled to keep the foot to the front. There is no arrangement so efficient. A shoe which aids the plate in holding the foot in an attitude of slight adduction should be made.

It is not necessary to fix the brace to the shoe, as it adapts itself to the foot completely and retains its position.

In the most favourable cases the brace should be worn from three to six months, and if any symptoms of trouble reappear it must again be used.

Other Patterns of Brace.—Sampson[1] turns up two outside flanges, one opposite the anterior end of the os calcis, and another about the middle of the fifth metatarsal. Celluloid has been used by Max David. He says it is light and elastic, and does not tear the boots and stockings. Lange uses a celluloid and wire plate. It is found by experience that the plates have to be remoulded and raised from time to time, the first alteration usually taking place at the end of a month. As the arch of the foot recedes upwards, the plate must be made to follow it.

Long experience in the use of Whitman's plate shows that with careful after-treatment one-third of the cases will be quite relieved within a year, one-twelfth will gain no benefit, and of the rest it may be said that they are considerably helped.

[1] *Amer. Medicine*, Jan. 1902.

Treatment of Severe Cases—Rigid, Spasmodic, and Fixed.—It is quite useless to attempt any treatment by the above appliances for a rigid deformed foot. Rigidity must be overcome and the deformity relieved first. Happily treatment is very successful.

In slighter cases the spasm yields to two or three weeks in bed, followed by passive inversion exercises (Fig. 545), massage, and the use of malleable iron splints or adhesive plaster (Fig. 546)

FIG. 545.—Forcible Adduction of the Foot—"Twisting"—the most important Manipulation in the Treatment of "Stiff" Feet (Whitman).

arranged so as to maintain the foot in the varus position. This is a tedious business, and valuable time is lost which could be more profitably devoted to the after-treatment of operative methods.

Operative Treatment.—Some surgeons tenotomise the peronei, but the experience of my friend Mr. Robert Jones, and of most of us, has been that with simple tenotomy the spasm invariably returns when weight is put upon the foot. Acting on a suggestion of his, the author adopts the following procedure:—

By the open method an inch of the tendons of the peroneus

longus and brevis is excised, and by the subcutaneous method the extensor communis tendon is severed. In all cases he forcibly redresses the foot. Under an anæsthetic it is thoroughly manipulated, and again and again forced in all directions to the full extent

FIG. 546.—The Method of applying Adhesive Plaster, after "Twisting," to support the Foot in Adduction (Whitman).

of its normal mobility. This may be done either with the hands or the Thomas wrench, or over the edge of a wooden wedge. If the tendo Achillis is shortened, it should be divided. When all the deformity is quite overcome, the foot is fixed in plaster of Paris in a position of complete varus, with the outer border

of the foot in the same plane as the leg, and at an angle of 90°.

The after pain is slight, whilst that due to the original condition is entirely relieved. Some surgeons let the patient walk in two or three days in plaster. This helps to correct the deformity, accustoms the patient to the new posture, and permits of functional re-adaptation of structure. With Kirmisson we prefer to keep them in bed for ten to fourteen days to allow the articular irritation to subside.

The duration of the plaster stage is usually three to six weeks. It must be removed once during this time to allow a brace to be modelled to the foot, and then re-applied. After the plaster stage, treatment is carried out by means of the Whitman brace; exercises and manipulations are used; and it is imperative that the surgeon sees to the details himself, or the case will relapse, the usual cause being the neglect of systematic manipulations. Almost every kind of rigid foot will yield to this treatment satisfactorily, if persevered in.

Operations on the Bones.—They have been designed for the relief of those cases in which ankylosis has occurred. The present writer feels he must express himself with great reserve, and the methods do not call for extended comment. Those which aim at the removal of the depressed head of the astragalus and scaphoid are most unsatisfactory afterwards. Ankylosis of these bones is difficult to obtain. Fibrous ankylosis will yield again under the abnormal static conditions, and true bony ankylosis is excessively rare. Methods of wiring and pegging the bones together have not proved satisfactory, and the procedure has been abandoned. In any case it is evident that functional cure is impossible. Some of the procedures which have been advocated are as follows:—

The Supra-Malleolar Osteotomy of Trendelenburg.—This is a particularly illogical procedure. It leaves the original deformity quite untouched, and seeks to compensate it by producing a second deformity in the opposite direction higher up. Happily the operation is now abandoned.

Astragalectomy.—The futility of astragalectomy in these cases must be apparent to all.

Gleich's Procedure.—This procedure, of advancing the tuberosities of the os calcis, does not commend itself to surgeons.

We need waste no more space on these matters, as the consideration of the causes of flat foot will teach us that it is of

no use further weakening the inner arch by ablation of any part of it.

Tendon - Grafting. — The following procedures have been carried out:—Shortening of the tibialis posticus by Hoffa and Francke; union of the tibialis anticus to the under surface of the first metatarsal bone by Francke; part of the tendo Achillis has been grafted into the tibialis posticus by Nicoladoni. The cases operated on by this method have not been sufficient in number to enable us to form any general conclusion on the subject.

In conclusion, it may be said that the term "flat foot," although sanctioned by long usage, is objectionable because it is not always accurate, neither is it sufficiently comprehensive. What we have to deal with in this condition is a weakness of the mechanism of the foot, whereby the normal relationship of the leg to the foot is altered. Any treatment which fails to recognise this fundamental point will be unsuccessful.

CHAPTER XV

STATIC DEFORMITIES OF THE TOES

Bunion (Hallux Valgus)—Pathogeny, Symptoms, and Signs—Treatment, Palliative and Operative—Hallux Rigidus, Flexus, and Extensus—Hallux Varus—Contracted and Laterally Deviated Toes—Acquired Hammer Toe.

HALLUX VALGUS (BUNION)

Synonym—*Hallux Extrorsus.* The affection is more properly called *Hallux Valgus.*

THE proper direction of the great toe in persons who go barefooted is in slight adduction, and in walking the toe becomes more adducted and somewhat flexed. Abduction of the toes is an artificial condition. It arises from the wearing of boots and is exaggerated by the demands of fashion.[1]

Hallux valgus (Figs. 547, 548) is a fashion deformity. It is more frequent in women in the higher social ranks, and is seen particularly in dwellers in towns.

Pathogeny.—Recent researches show that the pathogeny of hallux valgus or abducted great toe, and that of valgus or abducted foot, largely overlap. It is difficult to keep the two separate. Three excellent pamphlets on this subject should be referred to.[2]

[1] E. H. Bradford, *Trans. Amer. Orth. Assoc.*, 1902, p. 323, gives an excellent X-ray of the foot in the boot, showing the effect of foot-wear in producing hallux valgus.

[2] "Proper Foot-wear," by John A. Sampson, *Johns Hopkins Hospital Bulletin*, vol. xiii. No. cxxx.; Whitman, "Study of the Weak Foot," *N. Y. Med. Rec.*, Aug. 31, 1907; Hoffman, "Foot-wear and the Feet." In the last paper are numerous beautiful illustrations showing the undistorted feet of a child, a boy's foot without any shoe-deformity, the extent of the voluntary spreading of an infant's toes, and the plantar surfaces of the foot of a Philippino. Hoffman also gives illustrations from the statues of antiquity in which the normal adducted position of the great toe is shown. He then passes on to show the effect of interchangeable stockings in producing abduction of the great toes, and illustrates by numerous outlines and photographs the effects of boots in producing bunions and hammer toes.

Hallux valgus causes the patient to push the foot off the ground from the inside instead of using the proper heel-and-toe method of walking. This sets up abduction of the foot and flat foot. Still, in many cases the abducting boot is the cause of both,

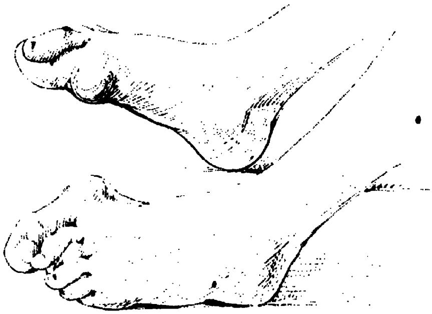


FIG. 547.

FIG. 548.

Two views of a case of Hallux Valgus and Bunions.

and they may arise *pari passu*. Again, flat foot by lengthening the foot causes crowding of the toes and hallux valgus.[1]

[1] In boots where the soles curve up towards the toes the great toe is held constantly in a position of extension or dorsiflexion. Now, with normal extension there is always some valgus. It therefore follows that, if the toe is continually held dorsiflexed, increased abduction must follow.

Skiagram of foot in shoe, from a case of Hallux Valgus, showing how the shape of a shoe causes the deformity (Bradford and Lovett).

To face page 711.

The faults most common in the boots of people who have bunions are:—

1. Insufficient room in the upper over the big toes. This is very usual in English-made boots.

2. The convexity of the sole of the boot downward keeps the great toe extended, and even hyper-extended, which favours abduction. With the toe in such a position the wearer "rocks off" the toe instead of using the flexor muscles of the toe. In a normal foot flexion and abduction of the great toe are simultaneous.

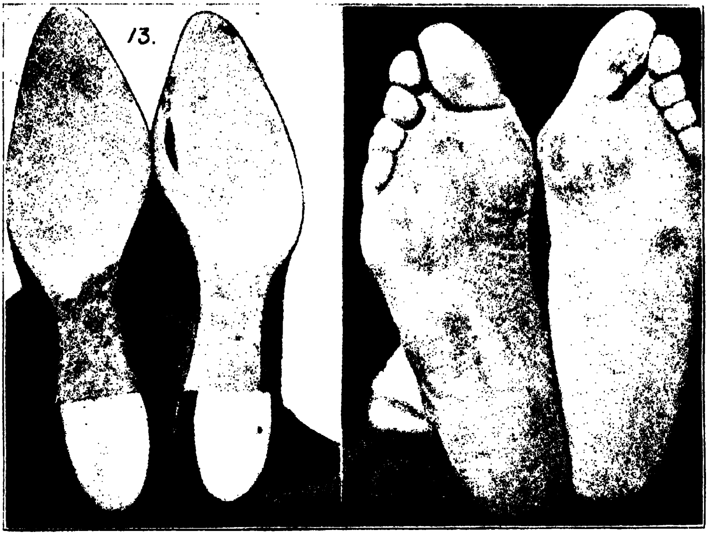


FIG. 549. FIG. 550.

A Predominant Type of Foot-Wear and its Inevitable Effect. The Shape of the Feet conforms to that of the Boots (Phil. Hoffman). Note the Hallux Valgus.

3. Soles of boots are also convex externally from side to side, and this favours descent of the great toe to the lowest and median portion of the sole (Plate XXXII.).

4. High heels, besides intensifying dorsiflexion, cause the foot to slide forwards, with crowding of the toes and more deviation of the great toe externally.

5. Boots with convex inner edges naturally push the great toe outward.

Symptoms and Signs.—The feature of the deformity is displacement of the great toe outward, with prominence inward of

the base of the proximal phalanx and head of the first metatarsal bone. But the deformity is not limited to the metatarso-phalangeal articulation. A considerable deviation outward takes place at the interphalangeal joints also. If the feet are placed side by side the curved axes of the great toes are well seen. As a result, the extensor proprius pollicis tendon is gradually displaced outward and

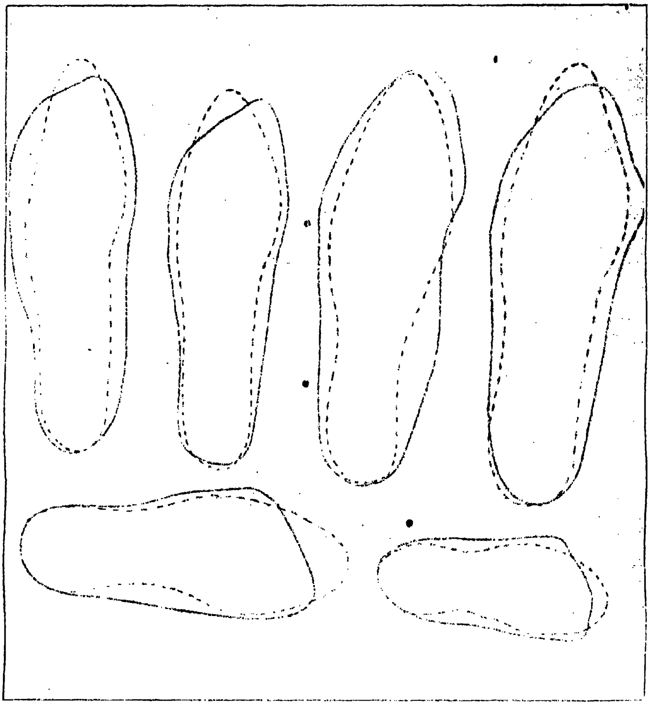


FIG. 551.—Outlines of Average Feet and Foot-Wear. The solid lines show the outlines of the feet; the dotted ones the outlines of the boots worn on those feet (Phil. Hoffman).

forms the chord of an arc. It also becomes gradually shortened and perpetuates the deformity.

Over the prominent portion of the base of the proximal phalanx and head of the first metatarsal the bone gradually becomes hypertrophied, and a thickening of the soft tissues arises, in which ultimately a false bursa is developed. This becomes inflamed and sometimes suppurates. We have seen extensive cellulitis of the foot arising from neglected bursitis.

A subluxation occurs as a result of the displacement, so that the internal lateral ligament is stretched. In some cases it is thinned, more often it is thickened, and occasionally it is perforated. Through the aperture the cavity of the false bursa communicates with the joint. The external lateral ligament is shorter and thicker than normal. The tendons of the muscles inserted on the inner side of the base of the first phalanx are lengthened, and that on the outer side is shortened. The joint itself is usually in a condition of dry inflammatory arthritis, which is often mistaken for rheumatoid arthritis. Indeed, the latter condition has been held to be a predisposing cause of bunion. But many patients who have bunions, with creaking in their great toe joints, show no other symptoms of rheumatoid arthritis. Still, both it and bunions are very common conditions, and it is not surprising that they sometimes co-exist.

The inner side of the head of the metatarsal bone is hypertrophied; and there is frequently seen a groove where the cartilage is thinned. A similar appearance exists on the inner edge of the base of the first phalanx. The inner enlarged edge of the base of that bone can be distinctly felt through the skin, forming a definite bony prominence. Pressure over this spot gives pain, which is caused by squeezing of the fibres of the anterior tibial nerve between the finger and underlying portions of bone. Many patients with bunion complain of pain at the outer as well as the inner side of the joint. The former is due, we believe, to nipping of the nerve fibres between the bony outgrowth on the base of the first phalanx of the great toe and the side of the first phalanx of the second. After the operation of excision of the head of the first metatarsal bone, we have occasionally had patients complain of persistent pain between the first and second toes. We have taken the precaution, therefore, of nipping off the prominent outer side of the base of the first phalanx, and the result has been entirely successful so far as pain is concerned.

When corns develop on the bunion they are extremely painful and often of large size. In one patient, from whose foot we dissected out a large bunion with a painful corn on top of it, we found on subsequent section of the part removed that the corn extended through the whole thickness of the bursa, nearly an inch.

In most cases the surgeon's attention is not called to the condition until pain, swelling, and redness compel the patient to seek his advice. As the great toe is displaced outwards, it rides

over the second toe and depresses the second and third phalanges, so that hammer toe complicates the deformity. Flat foot is almost invariably present with bunion.

Treatment.—In slight cases relief can be obtained by ordering a proper boot or shoe. Whitman[1] says that the sole of the boot should be strong, and be slightly thicker along the inner side, so that the sensitive joint may be inclined away from the upper leather. If reference is made to pp. 672-673, where faults in the boots worn by people with bunions are described, the details of proper shoes can be readily inferred from the text. Patients must wear right and left socks or stockings, with a separate compartment for the big toe. Morning and night the toe should be drawn inward several times so as to ensure methodical manual correction, and at night a wedge of cotton-wool is worn between the first and second toes. Attention is paid to the condition of the longitudinal or anterior arches, and they ought to be properly supported.

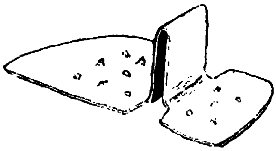


FIG. 552.—A Toe-Post, prescribed for Hallux Valgus, and often impossible to wear because of the pain it causes.

With reference to toe-posts in the boots (Fig. 552), the writer's experience has not been satisfactory. Unless extreme care is taken, the skin of the first interdigital space readily becomes irritated, and the patient discards the apparatus with disgust.

Various forms of bunion splints (see Fig. 553) are recommended, but very often the part is too tender and inflamed to bear any pressure. An excellent arrangement for these cases consists of a leather cap or thimble fitting over the great toe, secured by a tape which passes along the inner border of the foot and round the heel, and terminates in an elastic insertion which is fastened to the outer border of the foot by strapping. When the patient is unable to afford a special apparatus, a wedge-shaped pad fixed between the toes is of service; and the first toe may be separated from the

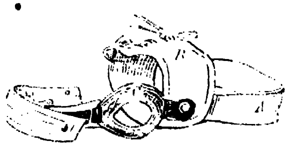


FIG. 553.—Spring for the Treatment of Bunion. A, Leather Band around Heel; B, Instep Strap; C, Steel Spring with Aperture in it, so as to avoid pressure on most prominent part of Bunion; D, Strap, which passes circumferentially round Great Toe. The effect of the Spring is to draw the great toe inwards.

[1] *Orthopedic Surgery*, 3rd ed. p. 741.

second by passing a piece of strapping round it, and fixing the other end of the strapping on the inner side of the heel. Some patients can wear splints of celluloid or rubber. In every case the greatest care must be taken to see that the boot is sufficiently broad to accommodate the foot and the corrective apparatus.

Operative Treatment.—The number of operations which have been performed for bunion is considerable, but few of them deserve extended notice. Removal of the false bursa alone is useless.

In cases of moderate severity the writer chisels off the prominent part of the head of the first metatarsal bone, divides the ligaments and the extensor proprius pollicis tendon, and replaces the phalanges in position. Many surgeons recommend cuneiform resection of the first metatarsal bone. The base of the wedge should be inward, and include the projecting portion of the head, if radiograms show such a projection to be at all marked.

In those cases where the head is greatly hypertrophied, the displacement of the phalanx is extreme, and the symptoms of dry arthritis are much marked, we excise completely the head of the metatarsal bone, taking care to remove the projecting spur on the outer side of the first phalanx. In all cases, too, we remove the sesamoid bones also, as experience shows that the pressure of the anterior end of the remainder of the first metatarsal bone on them sometimes causes pain. They can easily be dissected out, and their removal occasions no subsequent inconvenience. The importance of the inter-sesamoid pad is considerable. In the majority of cases where removal of the head of the metatarsal bone is done, this pad, composed of fibrous tissue covered by synovial membrane, is seen to be acutely inflamed (Fig. 555). It is swollen and deep red. As the bones approximate after the operation, the under surface of the distal extremity of the metatarsal bone exactly impinges upon it, and at each step a stab of pain is felt. C. H. Mayo recommends that the bursa be interposed between the joint surfaces after excision of the head. Section of the extensor proprius pollicis should also be combined with this operation. If it is left intact, the author has observed on several occasions that it becomes contracted, and causes dorsiflexion of the great toe.

When the wound is closed, a wedge of gauze should be placed between the first and second toes, and in order to secure subsequent movement the great toe is to be flexed and extended passively from the sixth day onwards. From the fourteenth to the twenty-first day the patient is able to walk about with a painless movable

joint. Inasmuch as the intact first metatarsal bone is an integral part of the arch of the foot, it is necessary for these patients to be supplied with a valgus plate for walking. The latter is prolonged forward on the inner side, so as to give increased support to the inner longitudinal arch.

Removal of the heads of the first metatarsal bones for bunion is a most successful operation, provided that the details we have alluded to are carried out. On two occasions we have operated with this object on both feet of dancing masters, and they have been able to follow their profession subsequently without pain or inconvenience.

Literature

In addition to the articles quoted on hallux valgus, or bunion, references are found in the works of Lüning and Schulthess, Max David, Bradford and Lovett, Whitman, Moore, Kirmisson, Berger and Banzet, Keetley, Jackson Clarke. Some of the references to recent literature are as follows:—

Delbet. Hallux Valgus. Rev. d'orthop., 1896, p. 221.

Steele. Trans. Am. Orth. Ass., 1898. With discussion.

Goldthwaite, Cook, Sayre, Bradford. Trans. Am. Orth. Ass., 1899, p. 242, and 1902, p. 323.

Roepke. Deutsche Zeitschr. f. Chir. Bd. 71, Heft 1.

Soison. Bull. et mém. de la soc. de chir. de Paris, 1901, No. 1.

W. J. Collins. Lancet, Apr. 15, 1899.

Ellis. Lancet, Apr. 29, 1899, p. 1155.

Jackson Clarke. Lancet, Mar. 3, 1900.

Poland. Lancet, Mar. 3, 1900.

Brit. Orth. Soc. Trans., 1900, with discussion by E. Muirhead Little, C. B. Keetley, A. F. Blagg, and the author.

Hallux Rigidus, Hallux Flexus, and Hallux Extensus

Synonym—Painful great toe joint.

These conditions are closely allied. In the earlier stages flexion or extension of the great toe causes pain. In the later stages all movement is restricted, and the toe is rigid. The late Mr. Davies-Colley stated that in advanced cases the deformity consists of a forced flexion of the proximal phalanx of the great toe from 30° to 60°, and in some instances the second phalanx of the toe is held rigidly in that position. Our experience does not confirm this entirely. Generally the first phalanx is held rigidly in a line with the head of the metatarsal bone, while the second is more or less free in its movement.

Symptoms.—*The head of the metatarsal bone is often*

enlarged, and there is at times some lipping of the cartilage at its inner and lower aspect, in the neighbourhood of the sesamoid bones. This is a point of importance in the pathology. Movement may be limited either in the direction of flexion or of extension, or lost altogether, and any attempt to elicit it causes extreme pain. Burning or throbbing in the joint is felt on standing or walking. The deformity is commonly seen in association with flat foot.

Ætiology.—The affection is more common in males than females, and occurs particularly from twenty to thirty years of age. Some cases are distinctly traceable to injury, as, for example, catching the great toe against some obstruction, or kicking against a stone, and patients trace it to walking on a rough mountain side over loose stones. The origin of other cases is found in a combination of flat feet and short boots. The toe is forced into the narrow part of the shoe, and is subjected to lateral and longitudinal pressure. It is therefore cramped in its movements, and the joint becomes the seat of traumatic arthritis.

Pathology.—In nearly all cases the head of the metatarsal bone is enlarged and the articular cartilage is eroded in places (Fig. 554); and certainly in advanced cases hypertrophic outgrowths form around the edges of the articulation. In all the cases we have operated upon we have not only noted this condition, but also one constant appearance, namely, hypertrophy and inflammation of the small synovial pad between the sesamoid bones (Fig. 555). This explains the constant tenderness which is felt on pressure on the sole of the foot over this spot. The inflamed pad is particularly well marked when hallux flexus is present, and any attempt to extend the phalanges causes pressure on the inflamed area. The rigidity of the toe is therefore at first reflex, but later it becomes fixed and ankylosed by the bony outgrowths.

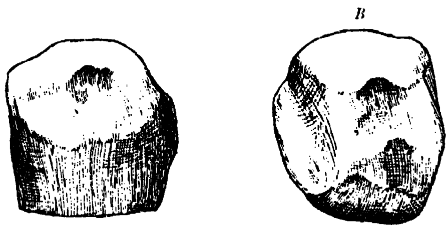


FIG. 554.—Two drawings from a case of Hallux Rigidus showing Erosions in the Cartilage on the under surface of the Head of the First Metatarsal Bone. In A, the less advanced condition, a single erosion is seen, which corresponds with the inflamed intersesamoid pad. In B the eroded condition is more advanced, and a second erosion is appearing.

Treatment is the same as that for hallux extensus, and is described on the following page.

Hallux Extensus

This affection is usually due to reflex contraction of the extensor proprius pollicis tendon arising from irritability of the joint, and later from periostitic thickening around the joint. As this becomes greater and the joint more painful, the toe is rigidly held in the extended position. That the conditions of extension and rigidity are reflex at first, is shown by the freedom of movement under an anæsthetic. In more advanced cases the joint becomes partially ankylosed by periarthritic and arthritic bony outgrowths. The synovial membrane is usually inflamed and hypertrophied. Fringes form at the edges of the articular surfaces, and later there is erosion of cartilage.

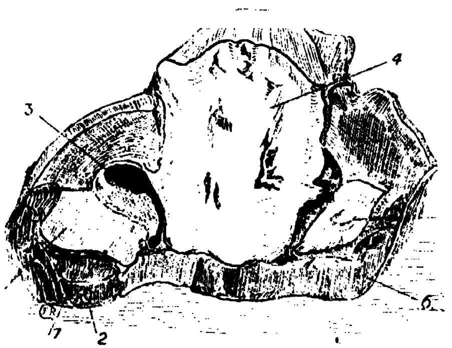


FIG. 555.—A sketch by Mr. E. Rock Carling of the Under Surface of the Head of the First Metatarsal Bone, with the Sesamoid Bones, from a Case of Hallux Rigidus, operated on by the author, and showing: 1 and 5, the Sesamoid Bones; on 5 an Erosion is seen; 2 and 6, the Cut Edges of the Thickened Capsule of the Metatarso-Phalangeal Joint; 3, a Synovial Sac on the Inner Side of the Joint; 4, the Under Surface of the Metatarsal Head, much eroded; 7, the Enlarged and Inflamed Intersesamoid Pad. The inferior part of the capsule of the joint has been laid open by a median antero-posterior incision, passing nearly midway between the sesamoid bones, and the soft parts have been turned inwards and outwards.

Treatment. — In all cases the patient is to be provided with a proper shoe, and flat foot should be attended to. Pressure must be taken off the joint by wedging up the inner edge of the sole and heel, and placing a bar or thickening behind the heads of the metatarsal bones.

In many instances strapping of the affected joint with Scott's ointment, and frequent bathing with hot water, followed by the application of liniment of iodine, will give relief. If these measures fail, or if the joint is evidently disorganised by arthritis, excision of the head of the metatarsal bone ought to be done, and particular care must be taken to excise the sesamoid bones, because of the inflamed pad of hypertrophied synovial membrane.

Hallux Varus, or Pigeon-Toe

This deformity is frequently met with in congenital equino-varus, and persists after rectification of the foot. It varies in extent, and the angle of displacement may be 45° or more. Anderson, in "Contraction of the Fingers and Toes," *Lancet*, vol. ii., 1891, mentions a case in which the angle was nearly 90°.

In a few of the congenital cases, although the feet and legs themselves are in good position, yet the inner band of plantar fascia is found to be contracted. Section of the contracted band is occasionally required.

Rotation inward of the great toes and feet is associated with bow legs, genu valgum, and that variety of coxa vara in which the neck of the femur is concave anteriorly.

Treatment.—When the condition is not secondary to deformity elsewhere, the outer border of the sole of the boot may be raised slightly—about $\frac{1}{8}$ inch. And if this is combined with appropriate exercises the condition soon disappears. Sometimes it is necessary to advise apparatus of a simple type, such as are used in the after-treatment of congenital club-foot, with the object of holding the feet in proper position.

A degree of pigeon-toe is physiological. It is only the marked deformity which calls for treatment.

Contracted Toes, and Toes Deviated Laterally

When these conditions are met with, and are not traceable to a congenital or paralytic origin, they are invariably due to squeezing the feet into boots too small. As a rule all the toes are deformed, being either crumpled, or twisted laterally as well, so as to over-ride one of the neighbouring digits. Corns and bursæ often form, and cause much discomfort.

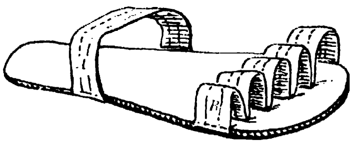


Fig. 556.—Leather Sole-Plate. A, the Band which fits around the Instep; B, Elastic Bands passing around the Toes.

Treatment. — Naturally the first point to receive attention is the foot-wear. Unless patients are sensible on this point, it is useless to proceed further. In the earlier stages the toes may be gradually straightened by frequent manipulations, and a leather

sole-plate (Fig. 556) worn at night. In severer cases, section of the flexor and extensor tendons and lateral ligaments is done; and a remodelling arrangement, such as the half-leather sole-plate, is used for some months, both in the daytime and at night, the toes being passively straightened several times morning and evening.

Acquired Hammer Toe is described on pp. 362-367.

CHAPTER XVI

MORTON'S DISEASE AND ANTERIOR METATARSALGIA

Types and Varieties—Morton's Disease or Metatarsal Neuralgia, Causation—Symptoms, Pathology, Diagnosis, Prognosis—Rigid and Non-Rigid Forms of Anterior Metatarsalgia—Treatment, Palliative and Operative.

THERE are several varieties of anterior metatarsalgia. We are able to differentiate at least two classes:—

(*A*) In which displacement of one bone only takes place in the anterior transverse arch. Examples of this are—(1) Typical Morton's disease, where spasmodic pain is focused around the head of the fourth metatarsal bone; (2) Depression of one of the metatarsal heads, not the fourth, comprising a part of the anterior arch.

(*B*) In which the whole anterior arch is depressed. In (1) there is depression of the entire anterior transverse arch, and the bones are held rigidly in their abnormal positions; (2) Depression of the anterior arch without rigidity.

All these have one factor common in their production, namely, the use of unsuitable boots.

MORTON'S DISEASE, OR METATARSAL NEURALGIA

(*A*) 1. The pain is situated about the head of the fourth metatarsal bone. Its causation is variously ascribed by patients. Instances are the following:—A gentleman, who played cricket a great deal, had been frequently struck by the ball on the dorsum of the foot. In addition he wore narrow, pointed boots. Another patient had, whilst wearing indiarubber shoes, trodden upon a stone. A third had knocked his foot against a stair, and felt something click about the head of the fourth metatarsal bone. Some have experienced the pain for the first time in rapidly descending a mountain side, and from others no history of any strain or wrench

can be obtained. One point in the history of many patients is that they feel a click about their toes and the pain comes on immediately, which can only be relieved by removing the boot and acutely flexing the affected toe. How closely the incidence of pain is dependent upon foot-wear (Figs. 557, 558) is seen by the constantly recurring statement: "I get no relief till the boot is removed."

Symptoms.—The pain is paroxysmal, and from the first it is limited to the neighbourhood of the fourth metatarsal bone. Thence it spreads along the foot and up the limb. In many patients the suffering is intense, and it has been such that we have known patients to remark that "they are willing to lose their foot in order to get rid of the pain." In fact it is crippling, and they are often unable to wear a boot at all. After a time the pain becomes agonising, and is evoked by very slight causes.

There may be no change to be noticed in the shape of the

FIG. 557.—A Transverse Section through the Heads of the Metatarsal Bones (Anterior Metatarsal Arch) of a Normal Foot.

FIG. 558.—A Similar Section, showing the Effects of Bad Foot-Wear on the Anterior Metatarsal Arch. The Heads of the Third and Fourth Metatarsal Bones are displaced downward, and the Anterior Arch is destroyed.

foot. As a rule flatness is absent, and very frequently there is no projection of the head of the fourth metatarsal bone in the sole of the foot. In other cases, however, this portion of bone is prominent. Sometimes a corn has formed in the sole over the affected area. If the head of the fourth metatarsal bone is firmly grasped between the finger and thumb, pain begins; also lateral pressure of the sole of the foot in the line of the heads of the metatarsal bones evokes the pain.

During the attack the appearance of the soft parts on the dorsum is not as a rule altered, although the author has on several occasions seen the tissues distinctly red and puffy during the attacks. This has led those ignorant of the nature of the affection to diagnose it as gout. Indeed, in many of these cases the patient will volunteer the history of gout or rheumatism, but the nature of the affection is not so. It is an alteration in the static relationship of the parts composing the anterior transverse arch.

A patient, no matter where he may be, must at all costs remove

PLATE XXXIII.

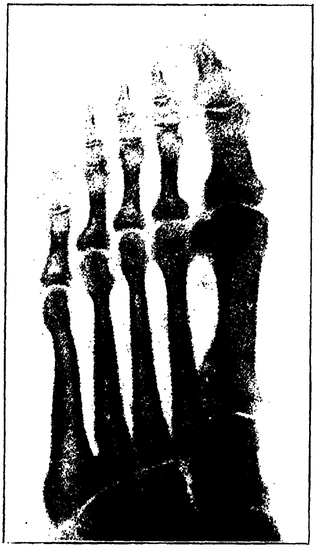


FIG. 1.

Skiagram of a Normal Foot, showing the Relationships of the Heads of the Metatarsal Bones. The head of the third adjoins the base of the first phalanx of the fourth, and the head of the fourth adjoins the base of the first phalanx of the fifth (Morton).

FIG. 2.

Skiagram of the Foot from a case of Morton Metatarsal Neuralgia. On account of the inward displacement of the toes the heads of the third and fourth metatarsal bones impinge on the base of the first phalanges of the fourth and fifth toes respectively (Morton).

PLATE XXXIII. (*Continued*).

FIG. 3.

Skiagram of a Foot from a Case of Morton's Disease, showing the effect of removal of the head of the fourth metatarsal bone (Morton).

the shoe when the attack comes on. He flexes and extends the foot and toes and rubs the part. The pain gradually goes, and its cessation is often synchronous with a distinct click, as if a subluxation of the first phalanx from the metatarsal head had been reduced.

After the attack some soreness is left, and the patient is more or less at ease until the next spasm is evoked by putting on the shoe and walking.

In several cases the writer has seen a peculiar twist in the foot. That part anterior to the tarso-metatarsal articulation is drawn inwards so that the base of the fifth metatarsal bone is exposed to the pressure of the boot, and there is constant pain at that spot. Pressure here gives rise to abduction of the head of the fifth metatarsal bone and stretching of the ligaments connecting the heads of the fourth and fifth bones, so that there is excessive mobility of their heads, and at some part of the arc of motion the digital nerves or their articular branches are compressed.

Ætiology.—Of all forms of metatarsalgia, Morton's disease is by far the most common, in the proportion of about four to one.

It attacks women more than men, probably because they use narrower shoes and higher heels than men. The affection appears in middle life, and is scarcely ever seen before the age of thirty years. It is met with more often in private than in hospital practice; and it is comparatively common in pregnant women.

Pathology.—Morton's explanation of the affection is as follows: —The heads of the first three metatarsal bones are nearly in a line and less movable than the remaining ones. The head of the fourth is a quarter of an inch behind that of the third, while the fifth is nearly half an inch behind the head of the fourth. Between the heads of the fourth and fifth, branches of the external plantar nerve pass; whilst the anterior extremity of the fifth metatarsal, and, to a less degree, the fourth, is very mobile. When the transverse arch is compressed, the head of the fifth metatarsal bone and its proximal phalanx come directly into contact with the head and neck of the fourth metatarsal bone (Plate XXXIII. Fig. 2), and therefore the nerves are compressed. Goldthwait points out that in many cases the first phalanx of the little toe is pressed against the head of the fourth metatarsal bone.

Whilst admitting that Morton's explanation of pressure on nerve-fibres is partly correct, yet it is difficult to see how the

trunks of the digital plantar nerves can be irritated. In the *Annals of Surgery*, September 1898, Mr. Robert Jones and I published a paper in which we showed by the examination of transverse sections of frozen feet that the exact position of a communicating branch between the internal and external plantar nerves is beneath the head of the fourth metatarsal bone; therefore if this is depressed the nerve must become irritated, bruised, or compressed.

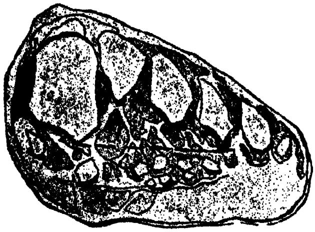


FIG. 559.—A Transverse Section of the Foot across the Heads of the Metatarsal Bones, showing the Anterior Metatarsal Arch (Jones and Tubby).

It is striking to observe, however, that in many cases patients complain not so much of pain in the soles of the feet as on the dorsum. Therefore in typical cases of Morton's disease, while we admit that the pain is due to pressure on the digital nerves or their branches, yet the exact site of pressure is variable. In some instances it is certainly due to irritation of the communicating branch before mentioned. In others it may be due to compression of the capsule of the fourth metatarso-phalangeal articulation and its small nerves, brought about by its being overridden by the base of the first phalanx of the fifth toe. Whitman, instancing parallel cases in the hand, says,[1] "If the metacarpal bone of the little finger is made to override the fourth, lateral pressure causes pain, usually of a more acute character than at the other joints, because the opportunity for direct pressure is more favourable. If firm pressure is made upon one or other side of the head of the depressed metacarpal bone of the dorsiflexed finger in the palm of the hand, a point of sensitiveness representing, apparently, the digital nerve can be made out. The same experiments may be tried upon the foot with like results, and they seem to make clear the mechanism of the pain of Morton's neuralgia, and the lighter forms of discomfort on the front of the foot."

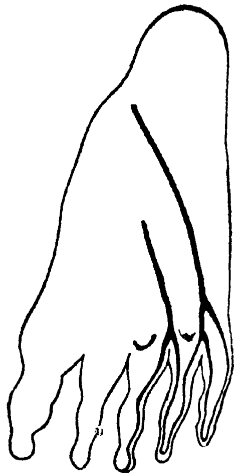


FIG. 560.—Diagram showing the Outlines of the Nerves generally trodden upon in Morton's Disease (Jones and Tubby).

[1] Whitman, *Orthopedic Surgery*, 3rd ed. p. 724.

As a rule, if the plantar digital nerves are examined, no change is visible in them, but in the course of operation for this condition the writer has twice seen the plantar digital nerves thickened and red; and once not red only but swollen, intensely congested, and dark, thus giving evidence of persistent neuritis.

As the affection progresses, the pain spreads from its site of origin to the other digital nerves, but it is never so severe in them. Pressure over the heads of the second and third metatarsal bones does not evoke so much pain as over the fourth. Therefore in Morton's disease pain spreads into other digital nerves from a focus situated about the head of the fourth metatarsal bone.

Diagnosis.—The history of the patient and the character of the pain are absolutely typical. But the condition is not so readily recognised as it should be, and patients are frequently treated for months or years for rheumatism or gout. In those cases of Morton's disease where puffiness and redness occur over the fourth metatarsal head the idea that gout is present is perhaps not unwarranted. Still, the incidence of the pain, its peculiar character, and the readiness with which it can be started by appropriate manipulation, should render the diagnosis clear.

In some cases the pain has been put down to flat foot, although in many instances no flat foot is present. Sometimes the reverse happens, and the longitudinal arches are better marked than in the normal.

Prognosis.—The affection is usually chronic. Occasionally, however, the symptoms may disappear spontaneously, and the author has known patients to say that a peculiar movement or click was felt in the fourth toe, and they have not experienced the pain since. This event cannot be relied upon.

The treatment will be dealt with when we have discussed other varieties of anterior metatarsalgia.

(*A*) 2. In some instances, instead of the fourth metatarsal head being the centre of the affection, it is occasionally most marked about the second or third. One of them is prominent in the sole of the foot, and over it a corn develops; while the joint itself is sometimes enlarged by exostoses. Irritating pain frequently accompanies the downward displacement. It is never so severe as in Morton's disease, and the chief cause of complaint arises from the tenderness over the corn and the false bursa which forms beneath it.

We must now pass on to Class *B*.

(*B*) Depression of the whole Anterior Arch

Whitman has insisted upon the importance of recognising the part which badly-made boots or shoes take in producing depression of the anterior arch. Many boots are constructed, the under surfaces of which are convex downward in the antero-posterior direction, or "rocker" soles. Many, too, are convex downward from side to side. The effect is twofold. The "rocker" sole causes dorsiflexion of the toes and depression and pushing down of the heads of the metatarsal bones. This is aggravated by wearing high heels which throw excessive strain on the front part of the foot. The side to side convexity has the effect of raising the first and fifth metatarsal heads, and causes the second, third, and fourth to sink downward, so that the third and fourth become prominent points in the tread. Narrow boots increase the malposition, and they also prevent that freedom and play in the anterior arch so essential to its integrity. In the normal foot, when it is off the ground, this arch is concave downwards, and when weight is placed upon it the arch is temporarily flattened. It is restored, when weight is removed, by its natural elasticity, which is dependent upon free play of all portions of the front part of the foot.

Now in some instances the depressed anterior arch remains absolutely rigid, and in others it is supple, but can be replaced with the hand. We have, therefore, two varieties of general depression of the arch, namely, the rigid and non-rigid.

1. *The Rigid Form.*—This variety is seen in those instances where the tendo Achillis is too short. The longitudinal arch is too high, and the patient therefore bears excessive weight on the front of the foot. In many cases of right-angled contraction of the tendo Achillis, and of the more marked degrees of talipes equinus, the height of the heel of the boot is gradually increased to make walking more easy, so that the abnormal condition of the anterior arch is thereby exaggerated. In many cases of paralytic talipes arcuatus and plantaris the toes are dorsiflexed owing to contraction of the extensor tendons, and this malposition of the toes pushes the metatarsal heads still further downward. The rigid and spasmodic condition of the anterior transverse arch probably arises in these cases from pain. It should also be mentioned that some of the non-paralytic cases are distinctly rheumatic.

Under the depressed heads a row of corns forms, which is

suggestive of the nature of the affection, and leads to inquiry into its cause. The pain differs entirely from that found in Morton's disease. It is neither spasmodic nor extreme, it is a dull ache made worse by tight boots, and is distributed over the whole arch, and it does not radiate so extensively. A good deal of it is due to painful corns, inflamed false bursæ, and the irritation of the nerve-supply to the metatarso-phalangeal joints.

2. *The Non-Rigid Form of Depressed Arch.*—This is synonymous with anterior flat foot. The transverse ligament bracing the heads of the bones has given way, precisely in the same way as the fibrous structures in the posterior part of the foot, and the anterior arch is therefore lost; but it can be restored by passive manipulation. Generally, corns are absent beneath the heads of the bones, and the pain is not great; in fact it is a mild type of metatarsalgia.

Treatment. (*A*) 1 and 2.—Of Morton's disease. It is essential to remove pressure from the digital nerves and the branches of distribution and the communicating trunks. It is found that if the bases of the metatarsal bones are grasped, the heads are separated somewhat; and a strip of adhesive plaster firmly applied in this situation often gives relief.[1] Boots should be low-heeled, and fit closely around the instep. They are made broad in the tread so as to give plenty of room to the heads of the metatarsal bones, and the soles must be thick. In addition, the latter are modified so that in treading the weight is brought behind the heads of the metatarsal bones and not upon them. This can be done in various ways. (1) Just behind the head of the fourth metatarsal bone a piece of felt about an inch wide and as broad as the sole of the foot, and from a quarter to one-half of an inch in thickness, with bevelled edges, can be fixed to the sole of the foot with plaster. The sole of the boot is hollowed out under the head of the fourth metatarsal bone so that very little pressure comes upon it. (2) A more satisfactory arrangement is thickening the sole of the boot from a quarter to half of an inch just behind the heads of the metatarsal bones, so that no pressure is made on them in walking. (3) In out-patient practice a bar of leather, one-third of an inch thick with the edges bevelled, answers the purpose quite as well. (4)

[1] By separating the heads thus, one of three things happens: either *A*, the impact of the fourth metatarsal head is no longer on the communicating branch between the external and internal plantar nerves: *B*, The finer nerve-filaments between the heads are not compressed: *C*, The main trunks of the digital nerves are not subjected to occasional squeezing by the excessive movements of the fourth metatarsal head and by rubbing against adjacent bones.

Sometimes a flat foot plate prolonged well forwards so as to support the metatarsal bones just behind their heads is useful. (5) Or a modified Whitman's brace, carried forward and adapted to support the anterior metatarsal arch, is very efficient (Fig. 561). In short, any measure calculated to prevent or to relieve the pressure on the heads of the metatarsal bones in walking is successful in mild cases.

It is curious to note how simple are some of the methods which give relief. Thus, a medical man, who had suffered for several years, wrote to the author informing him that he had cured himself by using digitated stockings, and placing a wedge of cotton wool between the fourth and fifth toes.

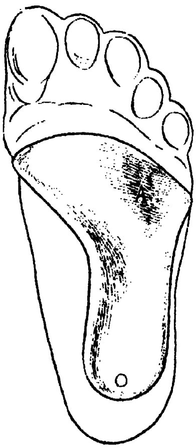


FIG. 561.—A Brace for Anterior Metatarsalgia. A, indicates a point beneath the fourth metatarsophalangeal articulation, which is elevated in order to support the depressed articulation (Whitman).

However, in many cases all these palliative methods fail and operation is indicated. Particularly is this the case when the disease has been of long standing and the nerves have become extremely sensitive.

In Morton's disease the operation which succeeds is excision of the head of the fourth metatarsal bone. It is easier to excise it from the dorsum than from the sole of the foot. In the worst type of case we have also excised a quarter of an inch of the plantar digital nerves. If the third or the second toes are more painful than the fourth, we excise the corresponding heads.

(*B*) 1. *Treatment of the Generally Depressed Arch.*—When it is due to right-angled contraction of the tendo Achillis, or to the paralytic forms of talipes arcuatus and talipes plantaris, the treatment is that of the primary condition (pp. 317, 324). If, however, the depression of the arch is associated with rheumatism and contraction of the toes, suitable exercises of flexion and extension of them are prescribed, and pressure is taken off the metatarsal heads by means of felt worn inside the boots, or by a thickening or bar outside the soles. The general condition of the patient should receive attention; and baths and local applications may also be of service. In some instances the corns are so bad that removal of them is required.

(*B*) 2. *Treatment of the Non-Rigid Depressed Arch.*—This is essentially the same as the treatment of flat foot, but pads or braces

are prolonged forward so as to assist in the restoration of the anterior metatarsal arch.

LITERATURE OF METATARSALGIA

MORTON. "Peculiar Painful Affection of the Fourth Metatarso-phalangeal Articulation." Am. Jour. of Med. Sc., 1876.

BRADFORD. "Metatarsal Neuralgia, or Morton's Affection of the Foot." Boston Med. and Surg. Jour., 1891, vol. xi. p. 523.

GIBNEY. "Non-Operative Treatment of Metatarsalgia." Amer. Jour. of Nervous and Mental Diseases, Sept. 1894, p. 589.

C. E. WOODRUFF. "Incomplete Luxations of the Metatarso-phalangeal Articulation." N. Y. Med. Record, Jan. 18, 1890.

GOLDTHWAIT. Boston Med. and Surg. Jour. cxxxi. No. 10, p. 233. "On Obliteration of the Anterior Transverse Arch of the Foot as a Cause of Metatarsalgia."

BOX. On "Morton's Disease." Archiv. gén. de méd., July 1894.

T. S. K. MORTON. Trans. Phil. Acad. of Surg., 1893.

EDMUND ROUGHTON. Lancet, March 1889.

DANA. Med. Rev. (N.Y.), July 1895.

GOLDTHWAIT. Trans. Am. Orth. Ass. vol. vii.

WHITMAN. Ibid. vol. xi. p. 36.

BRADFORD. Boston Med. and Surg. Jour. vol. cxxv. No. 23.

T. G. MORTON. Internat. Med. Mag., 1896, p. 322.

JONES and TUBBY. Annals of Surgery, Sept. 1898.

HARSANT. Bristol Med. and Chirurg. Jour., Sept. 1897.

HOFFMAN. St. Louis Courier of Med., June 1902.

PECKHAM. Trans. Am. Orth. Ass. vol. xiv. p. 201.

BRADFORD. Ibid., 1902, p. 329.

STERN. Amer. Med., Feb. 6, 1904.

GUISEPPE CRISTALLI. Archivio di ostetricia e ginecologia, vol. ix. p. 752, on Morton's Disease in Pregnancy.

A. MACKENZIE FORBES. An Operation for Anterior Metatarsalgia. Amer. Jour. Orth. Surg. vol. viii. No. 3, Feb. 1911, p. 507. The operation aims at overcoming the depression of the head of the metatarsal bone, by detaching the long extensor tendon from the toe, and inserting it into the head of the metatarsal bone.

SECTION IV

AFFECTIONS OF MUSCLES, TENDONS, BURSÆ, AND FASCIÆ

CHAPTER I

INJURIES AND DISEASES OF THE MUSCLES

Spontaneous Rupture—Traumatic Rupture—Contusion, Symptoms, Mode of Repair, Treatment—Ischæmia of Muscle, Ischæmic Contraction of Muscle (Volkmann)—Symptoms and Treatment—Myositis, Traumatic, Infective, Pyæmic, Syphilitic, Tuberculous—Myositis Ossificans, Pathology, Symptoms and Treatment—Osteoma of Muscle and Tendon, Symptoms and Ætiology, Pathology and Treatment—Hernia of Muscle, Congenital and Acquired, Symptoms and Treatment—Atrophy of Muscle, Tropho-neurotic. The Muscular Dystrophies—Thomsen's Disease.

INJURIES

IN various ways and by different methods, as we shall see later, the continuity of a muscle may be wholly or partially interrupted, the skin remaining intact, or being broken. So far as the muscle is concerned, the difference between the two conditions is closely analogous to those existing in simple and compound fracture, viz. the greater liability of the latter to infection when the skin is wounded. Apart from this distinction there is no need to lay special stress upon open or compound muscular injuries.

Spontaneous Rupture.—It may be said that spontaneous rupture, that is solution of continuity of a muscle, during normal contraction is almost unknown. In the convulsions of tetanus and eclampsia however, in the course of the violent movements of mania or delirium, or owing to the forcible involuntary contractions in parturition and vomiting, a muscle or muscles may give way. Some apparently spontaneous cases may be accounted for by the weakening effect of a degenerative process, such as enteric fever.

Traumatic Rupture.—The theories as to the causation and mechanism of rupture of muscle have been recently well discussed by Ombrédanne,[1] who states that—

[1] *Nouveau traité de chirurgie*, par A. Le Dentu et Pierre Delbet, fasc. ix., Paris, 1907.

1. *Rupture apparently by Contraction only*—as in tetanus, delirium tremens, eclampsia, and epilepsy—is so rare that this very fact indicates that mere contraction is incapable of causing rupture, and therefore some other condition is present. Various considerations have been invoked to explain the rupture. Thus Nélaton suggested a reflex, involuntary, unconscious contraction. The nerve-centres, which through the intervention of the muscular sense normally regulate the degree of useful contraction, are momentarily inhibited by danger or surprise.

Sédillot thinks that the muscular fibres do not contract simultaneously, and that partial and successive contractions are too feeble to effect the desired movement, so that the fibres involved give way.

Gübler believes that co-ordinate movement is the outcome of the synergic contraction of a group of muscles; that one muscle of many being accidentally set in action, it proves too feeble to carry out the movement, and ruptures.

Charcot and Couilland admit inco-ordination, but ascribe the accident to want of practice and skill. Thus, young soldiers rupture their muscles in executing movements, which trained men carry out without accident. They also suggest as another cause of clumsy action, reversion of the poles of functional insertion. Thus the rectus abdominis in an agricultural labourer has its functional origin at the pelvis and its insertion at the thorax—that is, it lowers the thorax. If we ask such an individual to vault on horseback without using stirrups—that is to make his rectus abdominalis raise the pelvis—the *rôles* of the insertions are reversed and rupture may occur. Again, the pectoralis major normally moves the arm whilst the thorax is fixed, in climbing the action is reversed.

Bichat and Delpech have suggested the brusque arrest of movement brought about by the too energetic action of the antagonistic muscles as a cause, *i.e.* the rupture is due to inco-ordination, owing to surprise, fear, or the execution of an unaccustomed movement.

In short, *manque d'habitude* both of the individual and of the muscle is the primary cause of abnormal, inco-ordinated, badly regulated and exaggerated contraction, leading to rupture.

2. *Rupture by Elongation of a Contracted Muscle.*—As an example we cite the case of a person descending a staircase, and his heel slips. In the effort to avoid falling backwards he ruptures his rectus femoris. This is due to the body weight being suddenly thrown on the already contracted muscle.

3. *Contusion of a Contracted Muscle.*—For example: The young soldier leaping into the saddle. As he falls into the saddle with his adductors contracted, these are contused by the tangential impact with the flanks of the horse, and give way. Rupture of muscle when produced in one or other of these ways is not uncommon and "contusion" is the usual cause. In this injury the skin is not as a rule broken. It should be mentioned here that, apart from rupture, contusion may set up a temporary inhibition or paralysis of muscle, lasting hours or days, and sometimes followed by more or less structural degeneration.

The muscles most frequently ruptured are, in running and leaping, the extensor brevis of the toes, the gastrocnemius and tibialis posticus; in falling backwards, the rectus femoris; in riding, the adductors and the biceps femoris; in climbing, the pectoralis major, biceps humeri, deltoid, and trapezius; and in parturition, the abdominal muscles. The external oblique has been ruptured by reapers, the sterno-mastoid by swimmers, and the pronator radii teres in lance-play.[1]

The lesion may be either in the mass of the muscle, or, as is more frequently the case, the muscular belly tears away irregularly from the tendon and retracts, leaving it with more or less muscle attached to it. The rupture may be

(*a*) Complete—leaving, however, the fibrous sheath intact.

(*b*) Partial—a portion of the muscle and tendon being left intact, a wedge-shaped gap results.

(*c*) Fibrillar—a few fibres only giving way, and a hæmatoma, either diffuse or localised, being formed.

Symptoms.—At the moment of rupture a sharp cutting pain is experienced, accompanied by a sensation of something having given way. Indeed the snap may be actually audible. The patient often feels as if he had received a sharp blow with a stick or stone. This is especially the case with the calf muscles, "and the French term, *coup de fouet*, as applied to this sharp pain is very graphic." [2]

Disability and pain follow immediately on attempted movement, the whole of the synergic group, of which the injured muscle is a

[1] "Perhaps one of the most frequent injuries of the kind is tearing of the extensor brevis of the foot, due to 'turning the ankle under,' as it is called. The contracted ends of the torn muscle may be easily felt, as well as the collection of blood between them" (Holmes' *System of Surgery*, 3rd ed. vol. ii. p. 160). Ombrédanne states that the most frequent instance of rupture is that of the sacro-lumbar mass. The muscle gives at the moment an effort is made to lift a burden.

[2] Sir F. Treves, *System of Surgery*, vol. ii. p. 5.

member, being thrown out of gear. Possibly a gap may be felt, or there may be a depression in the overlying skin, and later a hæmatoma develops. The symptoms vary with the circumstances as to whether the rupture is complete and if it is situated in an accessible position; or, if partial, as to whether it is on the superficial or deep surface of the muscle; and, finally, upon the presence of hæmorrhage, its amount and locality, whether deep in the tissues or beneath the skin.

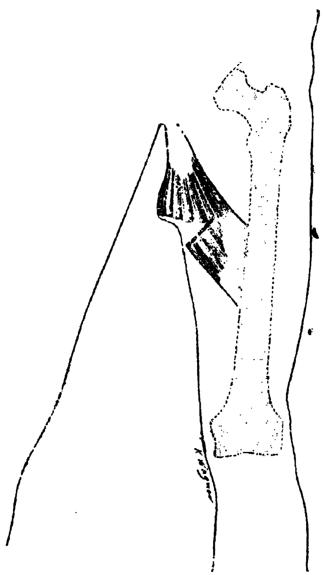


FIG. 562.—Ruptured Muscle during Contraction (Ombrédanne).

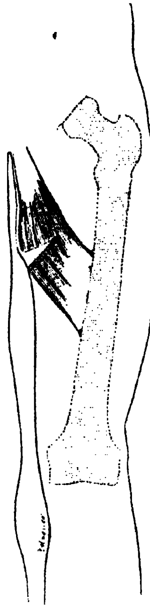


FIG. 563.—Ruptured Muscle in Repose (Ombrédanne).

The pathognomonic sign, when the conditions are favourable for its appearance, is the production of a condition most unfortunately named "muscular pseudo-hernia" by Farabeuf. If the ruptured muscle is made to contract, especially if the movement is resisted, a swelling appears. This is due to the hardening of the belly of the muscle on contraction, and its retraction towards its origin. The swelling is present during contraction (Fig. 562), and disappears during passive movement, or when the muscle is at rest (Fig. 563). It varies in size according to the position and completeness or otherwise of the rupture, and the relation of the lesion to

the position of the nerve-supply. The swelling is greatest when the rupture is complete and takes place near the tendon of insertion, leaving a considerable muscular mass, with the nerve-supply intact. Such conditions are met with in rupture of the adductor longus just below the pubis.

Patients are as a rule young and vigorous males. Rupture of tendon is most frequent; then in decreasing number, partial, and finally complete muscular rupture.[1] As a rule each muscle gives at one particular spot, the rectus abdominis in its sub-umbilical portion, the adductors at their middle, the biceps cubitis at the

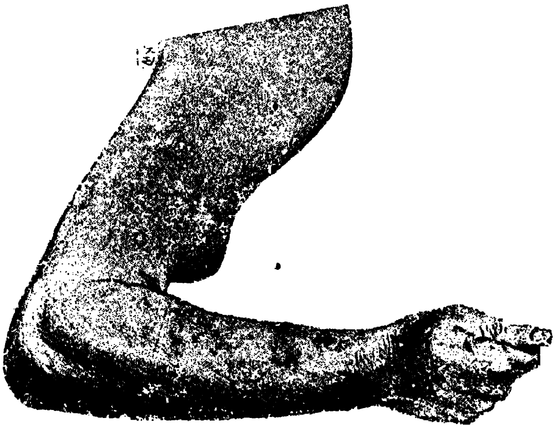


FIG. 564.—The Swelling caused by a Ruptured Biceps, when an attempt is made to Contract the Muscle (Ombrédanne, after Loos).

union of its lower fourth and upper three-fourths (Fig. 564), the rectus femoris at its centre or near the patellar tendon (Ombrédanne).

Farabeuf's pseudo-hernia must not be confused with the encysted hæmatoma often seen at a later stage. The gap between the ends is always the site of more or less effusion of blood. This may form a hæmatoma, generally slow in development, and often enlarging by successive stages, owing to fresh hæmorrhages from the newly formed vascular connective tissue.

Repair.—Much discussion has taken place as to the possibility of muscular regeneration;[2] but most authors are agreed that, if it

[1] Charcot and Couilland saw no less than 20 cases of partial rupture of muscle in a cavalry regiment in fifteen months.

[2] Cf. the writings of Waldeyer, Zenker, Maslowsky, Weber, Volkmann, Busse, and Blencker.

takes place at all, it is very slight in amount. Practically, union is by fibrous tissue, and invariably so if the torn ends are not kept in contact. An important point, and one bearing on treatment, is that if the peripheral fragment is separated from its motor and trophic nerves, it degenerates and atrophies.

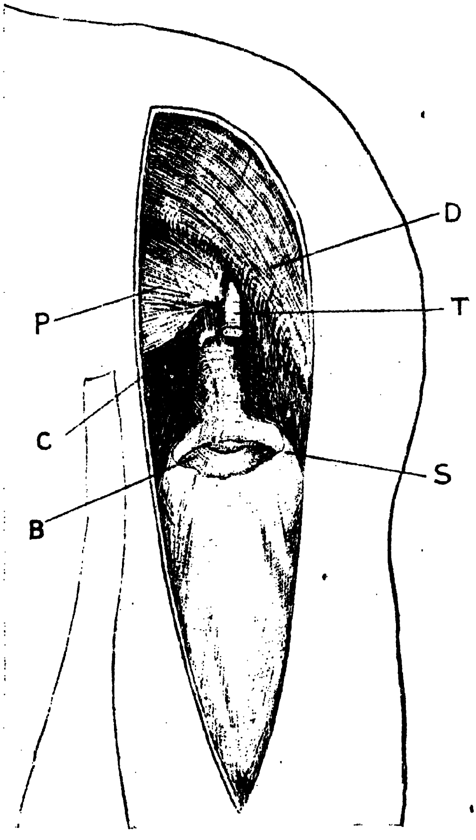


FIG. 565.—Rupture of the Biceps Humeri. A drawing by Mr. E. Rock Carling from a case occurring in a man, aged 33 years, and operated on by the author. The drawing shows the state of the parts when the lesion was fully exposed. P, Pectoralis Major, cut across; C, Coraco-brachiales and Short Head of Biceps; D, Deltoid; T, Tendon of Long Head of Biceps; B, Muscular part of Biceps retracted within its sheath, S.

Treatment.—Intermusculo-tendinous ruptures do not consolidate well, and should always be sutured, as was done in the author's case illustrated by Fig. 565. Intermuscular rupture of an important muscle certainly ought to be operated on, so as to restore

its integrity, and to obviate the disadvantages which may accrue from an encysted hæmatoma, or from ossification-changes in the muscular callus, or from degenerative changes in the peripheral fragment. An interlocking suture should be used so as to prevent the material cutting through.

Minor points in treatment are the necessity of immediate rest, approximation of the fragments by placing the parts in suitable position, and arrest of hæmorrhage by pressure immediately the accident occurs. In the later stages of treatment, massage and electricity of the remaining muscles of the synergic group are invaluable in order to prevent degeneration.

Instead of the hæmatoma, due to effusion at the time of the accident, subsiding steadily, it is found in some instances that a sudden increase in size takes place later. This is due to secondary hæmorrhage into the blood cyst from its vascular walls. In a case under the care of my friend Mr. Vincent Moxey, of "open" rupture of the muscles of the fore-arm, where all bleeding was arrested immediately after the accident, a violent outburst of hæmorrhage took place eight days afterwards, necessitating ligature of the ulnar artery, which was found entangled in the wall of a large blood cyst.

Myositis

Inflammation of muscle may be due to—

I. Direct infection—that is, myositis in connection with an infected wound.

II. The circulation of the toxic products of bacilli—that is, septicæmic myositis; and then it is generally of a degenerative type.

III. The presence and multiplication of bacilli in the muscles. It is then pyæmic or metastatic, and often purulent in character.

Suppurative and non-suppurative myositis are not strictly synonymous with the pyæmic and septicæmic groups, because bacilli may be present in an inflamed focus, and yet not cause pus formation, owing to their low virulence and attenuation. Also certain organisms, *e.g.* those found in acute rheumatism, do not set up suppuration, while others, *e.g.* the syphilitic, rarely do so. Again, a degenerative myositis may be purely toxic from the start, and, as in typhoid fever, may lead to muscular rupture and

hæmatoma. The hæmatoma then becomes infected, and an abscess results; that is, the toxic and pyæmic factors become intertwined.

Classification, therefore, must be broad, provisional, and subject to qualifications.

Examples of myositis from direct extension of disease are, psoitis in connection with a psoas abscess; lumbar abscess in spinal disease; abscess of abdominal wall, due to extension of suppuration from the subperitoneal tissue. As we shall see, primary tuberculous myositis is rare; such cases being nearly always due to direct extension.

Toxic Myositis.—It is not easy to draw a hard and fast line of demarcation between an inflammatory and degenerative muscular process in all cases; indeed, much depends on the point of view of the observer. Further, in certain cases we do not know whether the process is purely toxic, or is in part due to the presence of an organism of low pus-producing power.

A myositis of toxic character is met with in certain infective conditions — notably typhoid and scarlet fever, syphilis and rheumatism. Typhoidal myositis was first studied by Zenker,[1] and since by Waldeyer, Erb, Hayem, and Kiefer.[2] The importance of Zenker's degeneration, from a surgical point of view, is that the liability to muscular rupture is greatly increased when it is present. For a description of the degenerative processes involved, special works must be consulted.

The painful muscular conditions associated with chronic rheumatism are well known clinically, but pathologically the ground is as yet none too sure. The process is a sub-acute or chronic interstitial myositis. It leads to a hyperplastic proliferation of the connective tissue, with some atrophy of the muscular elements. The characteristic symptoms are intermittent and remittent pain; and the affected structures are tender, stiff, and painful on movement. The muscles generally affected are the lower spinal and the lumbar, the intercostals, trapezius, deltoid and occipito-frontalis, giving rise respectively to lumbago, pleurodynia, torticollis, and other characteristic signs.

In order to spare the painful muscle, contraction is set up in neighbouring groups. Thus in rheumatic myositis of the deltoid, the pectoralis major, latissimus dorsi, and teres major are contracted,

[1] Zenker, *Über die Veränderungen der willkürlichen Muskeln in Typhus Abdominalis*, Leipzig, 1864.

[2] "Myosite dans la fièvre typhoïde," Thèse de Paris, 1895.

but not themselves painful. If the trapezius is affected, the sterno-mastoid is contracted.

Recent pathological work lends itself to the view that in chronic rheumatic diseases we are dealing with an imperfect or delayed elimination of the causative organism,[1] and herein lies the clue to treatment.

Syphilis affects muscles in several ways :—

I. Syphilitic myosalgias in the early stages.
II. Syphilitic contracture, especially of the biceps cubitis.
III. Gummata of muscle in the tertiary stage.
IV. Diffuse infiltration of the later stages also.

Types I., III., and IV. are sufficiently described in the text-books on "Surgery," but about Type II., syphilitic contracture, a few words must be said.

This form, first described by Notta, has been called by Maurice "syphilitic affection of the biceps," on account of the special predilection of the disease for this muscle. The contracture comes on slowly and painlessly. When it is fully developed, the fore-arm cannot be extended beyond the right angle, and any attempt to do so provokes pain localised about the junction of the muscle with its tendon; flexion, however, is normal. The condition disappears spontaneously in the course of months or perhaps a year or so, and leaves no trace behind, thus showing that no structural contracture has occurred.

Syphilitic contracture has also been seen in the flexors of the thigh, sterno-mastoid and masseter.[2]

It has been stated that mercury had little curative effect, but recent observations disprove this.

[1] Adami, *Principles of Pathology*, 1909, p. 425. "The more recent work upon the ætiological relationship of acute and chronic rheumatism, especially in connection with Poynton and Paine's organism (*Lancet*, November 11, 1905, 860 and 932), is given by Beattie, *Journal of Medical Research*, 14, 1906, 399. We fail to see that any ætiological distinction can be drawn between the acute and chronic remittent type; indeed in our laboratory at the Royal Victoria Hospital, from the disorganised hip-joint of a man who had suffered from such remittent rheumatism for twenty years, and was wholly crippled thereby, we gained abundant diplococci, which, cultivated by D. G. A. Charlton, exhibited all the characters of Poynton and Paine's organism."

[2] Some references to syphilitic contractures of muscle are: Virchow, *Archiv f. path. Anatomie*, vol. iv. p. 271; Ricord, *Gazette des hôpitaux*, 1842 and 1846; Boyer, *Traité pratique de la syphilis*, 1838, p. 167; Notta, *Archives gén. de méd.*, December 1856; Lancereaux, *A Treatise on Syphilis*, New Sydenham Soc.; Prost, "Myopathies syphilitiques," Thèse de Paris, 1891; Kohler, "Syphilis of the Muscles," *Berlin. klin. Wochenschr.*, 1894, p. 162; Martinet, Thèse de Lyon, 1903.

Ischæmic Myositis

My revered master, the late Professor von Volkmann of Halle, described in 1875 and more fully in 1881 a condition of contracture occurring more often in the fore-arm and hand, rarely in the leg, and following rapidly on the use of bandages applied too tightly. Volkmann believed the contracture to be of ischæmic origin, dependent upon the arrest in varying degrees of the arterial blood-supply, and therefore of oxygen to the muscles. As a result, the contractile substance coagulates and breaks down; and in effect a state of rigor-mortis or necrobiosis is established. The accompanying venous stasis, due to constriction or pressure, causes exudation into and between the muscles, hastens the onset of the paralysis, and in severe cases renders them intractable to any form of treatment.

Volkmann pointed out that the paralysis and contracture come on almost simultaneously or nearly so, whereas if contracture is due to nerve injuries alone, it comes on gradually and some time after the injury. In ischæmic contracture there is great rigidity from the first, which increases later owing to the formation of scar-tissue. The deprivation of blood is only partial, otherwise gangrene must ensue; but the severity of the contracture is directly dependent upon the degree of deprivation of arterial blood, and the prognosis varies with the amount of muscular tissue affected.

While Volkmann's views as to the muscles being the parts chiefly affected are generally received; yet as we shall see there is ample clinical evidence that in more than one-half of the cases an ischæmic neuritis occurs.

Causation.—It has been stated "that muscle may be wholly deprived of its blood-supply for many hours without any interference with its metabolic processes." [1] But such a statement is dangerous and inaccurate. Adami [2] depicts the wax-like degeneration of muscle which follows on temporary ligature of the main artery. It comes on very rapidly, and in the example figured by him the muscular changes were observed in seventeen hours.

Any lesion, then, which interferes with blood-supply to the limb initiates those morbid changes which result in contracture, and they are intensified when the freedom of the return venous flow is checked.

[1] Beattie and Dickson, *General Pathology*, 1908, p. 110.

[2] *Principles of Pathology*, 1909, p. 900.

The actual *causes* are fractures, usually of the humerus near the elbow joint, or of the fore-arm, and fixation by one method or another, sometimes combined with tight bandaging, but not always so. The bandage is by no means always to blame, for in Hoffmann's[1] case in a child, aged $5\frac{1}{2}$ years, the humerus was fractured close to the elbow. No bandages or splint, only a sling was used, and the ischæmic contraction was due to occlusion of the brachial artery at the site of fracture. In one case of our own, contraction of the muscles of the wrist and hand followed fracture of the coronoid process of the ulna by direct violence, the brachial artery presumably having been compressed against the bone by the injury. In other instances there has been reason to think that the coats of the brachial artery have been injured, and its lumen more or less occluded. In effect, any prolonged disturbance or arrest of the arterial supply produces the muscular, and in many cases it may be added, the nervous changes. Thus Volkmann's contracture has followed embolism, as in the cases of Langer and Schloffer; whilst endarteritic changes, such as are met with in dysbasia angio-sclerotica (vol. i. sec. ii.), are accompanied by cramps and hardening of the muscles. Similar effects on the muscles are seen in Raynaud's disease, syphilitic endarteritis, and after exposure to cold; but we are not aware that the characteristic deformity of the limb ever complicates these cases.

Simple contusion of the limb without fracture as in Barnard's, Dudgeon's, and Ward's cases, where there had been local injury to the vessels and effusion into the tissues with pressure on the arterial and partial interference with the venous blood flow, has caused the contracture. It has been noted also that, when a tight bandage has been used for any reason whatsoever, the muscular degeneration has commenced at the highest point of constriction and spread downward. Therefore the too prolonged use of an Esmarch's bandage, particularly in the arm, is to be avoided, and we certainly fear that similar cases will occur from the routine use of Bier's congestive treatment, where it is carelessly and improperly employed. So far none have been reported to our knowledge, but if the management of it is confided to imperfectly trained persons, disaster is bound to follow sooner or later.

There are then two factors in the production of ischæmic paralysis of muscular and nervous origin.

[1] E. Hoffmann, *Zeitschr. f. orth. Chir.* xix., 1907, p. 31.

A. Temporary and partial deprivation of arterial blood-supply, generally lasting longer than three hours.

B. Interference with the venous return of blood.

The presence of these factors is essential. If the arterial supply is completely interrupted above for a time, so that no more blood can enter the limb, flaccid paralysis follows;[1] but if both the arterial and venous flows are partially arrested, then degenerative tissue-changes follow.

J. Jenks Thomas[2] has written the most complete article on "Ischæmic Paralysis and Contracture," and has collected 107 cases. He has tabulated them in detail, and we avail ourselves of a most interesting analysis by him as to the site and nature of the primary injury.

Of 107 cases, 102 were in the arm and 5 in the leg.

ARM

Fracture of the Arm, region not stated	5
" " Humerus, part not stated	4
" " " middle	1
" " " above the condyles	28
" " " into elbow joint	15
" " Fore-arm, middle or upper	24
" " " lower	5
" " Radius	5
" " Fore-arm, region not stated	2
Dislocation, both bones of fore-arm	2
Fracture of the clavicle and tight bandaging	1
Contusion of fore-arm	6
Elastic bandage	2
Septic infection of arm	1
Embolus of arm	1

LEG

Splint for fluid in knee	1
Fracture of both bones of leg	1
Rupture of popliteal artery	1
Injury of leg at operation	1
Embolus	1
	107

"The treatment of the primary injury was as follows (but often it was stated that the splints and bandages were lightly

[1] J. Jenks Thomas, *Ann. Surg.*, March 1909, p. 351, and his view is supported by Bernhardt, Kobner, and von Frey.

[2] *Ann. Surg.*, March 1909, pp. 330-371.

applied, and at times that the splints were of pasteboard or of a similar character):"

Splints	52	cases
Splint, in case of stab wound or in infection	2	,,
Plaster of Paris	28	,,
Apparatus	1	,,
Bandage	2	,,
Sling	1	,,
Quiet	3	,,
Not stated	18	,,
	107	

It may be a matter of surprise that so few cases are found recorded, as every orthopædic surgeon of experience can recall at least eight or ten as coming under his notice, and some many more. As blame may be laid, often unjustly, on those who have treated the patient in the first instance, there has naturally been some hesitation in publishing the cases.

Referring to the exact mechanism of production of the contracture, we are unable, owing to consideration of space, to go fully into the experimental aspect or, to discuss the views of Leser, Wallis, Edington, Bardenheuer, Hoffmann, Hildebrand, Oppenheimer, Kleinschmidt, and Jenks Thomas, but they are summarised in the article[1] by the last named.

Pathology.—An important point has, within the last few years, been made quite clear. We have to deal in all cases with a myositis, and in a majority with neuritis as well. Jenks Thomas has pointed out that in 62 of the 107 cases evidence of nerve-involvement was present; and Wilfrid Harris[2] in 7 of 9 cases, additional to Thomas's, found reaction of degeneration, anæsthesia in the ulnar distribution, and other signs of neuritis.

We therefore consider the changes in muscles and nerves.

In the *muscles*, if abnormal pressure has existed for more than three to six hours, the contractile tissue undergoes rigor mortis, and necrobiotic changes set in, with rapid degeneration and shortening. While the pressure on the larger vessels is going on, and more particularly when it is removed, marked effusion takes place, and round-celled infiltration of the soft tissues commences. The muscle is more or less replaced ultimately by connective tissue, and, as time goes on, the cicatrix becomes harder and shorter.

[1] *Ann. Surg.*, March 1909, pp. 330-370.
[2] "Ischæmic Myositis and Neuritis," *Brit. Med. Journ.*, 1908, vol. ii. p. 919.

In operating on the muscles for the contracture, they are found to be firmer and harder than normal, and of a yellow colour, and are frequently matted together. Molitor, eight days after the injury, amputated the arm in a case of dislocation of the elbow with injury to the brachial artery. "The fore-arm muscles were but little changed (to the naked eye?),[1] being œdematous; the veins were full, and in some places there was round-celled infiltration; while (microscopically)[2] the muscle fibres were larger than normal, œdematous, homogeneous, somewhat irregular in outline, with loss of the transverse striation, and marked diminution of the nuclei. The nerves were not examined." Leser found in the muscle an increase of connective tissue and loss of the nuclei. Bemerys noted irregularity of the muscular fibres, the presence of vacuoles in some, absence of nuclei and loss of transverse striation in others. In advanced cases, round-celled infiltration, increase of connective tissue, and finally atrophy and disappearance of muscle fibres took place.

The microscopical changes, then, are gradual disappearance of muscle-nuclei and muscle-fibres, increase of interstitial connective tissue, and replacement of the fibres by the same substance.

The naked-eye appearances of the nerves are noteworthy. Davies-Colley found both the median and ulnar nerves small and purple in colour below the scar tissue in the fore-arm. Wallis observed that the median nerve was surrounded by scar tissue, and Bardenheuer noted that the median nerve in one case, and both the median and ulnar nerves in another, were narrowed by scar tissue. Ferguson noted the median and ulnar nerves to be nodular in places and smaller than normal, and Cushing found the ulnar nerve flattened and anæmic. In the first case of ischæmic contracture which came under our notice, the anterior interosseous nerve of the fore-arm was small and was embedded in a mass of fibrous tissue, which was traced from a depressed scar over the coronoid process of the ulna, and extended to the wrist. The scar tissue was dissected away, and recovery followed in twelve months.

It is evident, then, that the nerves are affected secondarily by pressure caused by scar tissue; whether they are primarily affected is a moot point. It is quite probable that the latter is the case, and there is no reason why the nerves should escape the immediate effects of ischæmia when the muscles suffer, and suffer so badly.

The skin often shows a lesion. In 37 of 107 cases, a slough, or a scar from a former slough, was present, and various trophic changes,

[1] and [2] These insertions in brackets are the author's.

such as coldness, cyanosis, shiny skin, ulcers on the fingers, and blebs, were noted 37 times (Jenks Thomas).

Sex.—The lesion is more frequently seen in males. Of 89 cases in which the sex was recorded, 62 were males and 27 females (Jenks Thomas).

Age.—Of 81 cases where the age was given, the youngest was 2 years, the oldest 50 years, 66 were 15 years or less, and 62 were 12 or less.

Symptoms depend upon the degree of ischaemia and its duration; if at all severe, the patient soon begins to complain. Pain is frequent and prominent, and is felt immediately after the application of the tight bandage. If this is not removed, the pain becomes worse, the hand and fingers swell and become discoloured,

Fig. 566.

Fig. 567.

Ischaemic Paralysis of the Hand (Robert Jones).

and blebs appear. In 24 hours the hand assumes the claw-like shape (Figs. 566, 567); and if the bandage be not removed, necrosis of the skin and flexor muscles may take place a short distance below the elbow. This was recorded in 60 per cent of Schramm's cases (Alfred S. Taylor).[1]

It is noteworthy that it is the flexor muscles, and particularly those on the ulnar side, which are affected. Why this should be so is difficult to say. The ulnar and radial vessels lie on the anterior aspect of the fore-arm, and the ulnar artery is more easily compressed against the bone in its upper part than the radial, which may account for it.

When the splint is removed, the muscles are felt to be hard to the touch. The elbow is flexed, the fore-arm pronated, the wrist slightly flexed, and the fingers strongly clawed. All attempts to

[1] *Ann. Surg.* vol. xlviii. p. 396.

extend the fingers, even in any position, cause the affected muscles to stand out prominently. A. S. Taylor observes that "in the severest cases the contracture is sufficient to drive the finger-nails into the palm of the hand."

If the nerves are primarily damaged, loss of sensation, either partial or complete, is noted at once. Later on, the nerves may undergo compression from scar tissue, and trophic and sensory changes ensue. Cases, however, vary greatly; we have depicted a case of medium severity.

Diagnosis.—The symptoms are characteristic in that the onset of loss of function, of flexor contracture and rigid resistance to extension is simultaneous. Paralysis due to nerve-injury is otherwise. The muscles are flaccid from the first and allow passive movement in any direction. There is no discoloration and no swelling of the fore-arm and hand, and no signs of a constriction by a bandage.

It is also necessary to diagnose it from hysterical contracture, infantile hemiplegia, athetosis, and diplegia, or from neuritis alone. From hysteria, a strong faradic current often serves to distinguish ischæmia, whilst the diagnosis from infantile hemiplegia, athetosis, and diplegia should present no difficulty. From uncomplicated neuritis the diagnosis is readily made, but it is otherwise when ischæmic neuritis is present.

We should endeavour to determine if in this form of the affection the nerves have been involved early or late in the process. "If the muscle responds, even though faintly, to both faradic and galvanic currents there is no nerve injury; if to galvanic, but not to faradic, there is nerve injury; if to neither galvanic nor faradic current, there is complete muscle injury; nerve injury not being determined. In this last contingency help may be derived from an examination of the intrinsic muscles of the hand, which are seldom or never involved in the ischæmic lesions. According to the reactions of these muscles, it can be determined whether or not nerve impulses pass through the damaged areas above, and therefore whether the nerves are damaged" (Alfred S. Taylor).

Prognosis.—These cases are as a whole unfavourable, as is shown by the many forms of treatment employed and their want of success. Much, however, depends upon promptness and energy; the sooner treatment, preventive and otherwise, is begun and the more assiduous it is, the better is the outlook. Complete cicatrisation of muscle is hopeless, partially cicatrised muscle may be rendered

useful, and between the slight and extreme cases there are many degrees of recovery.

Treatment is Preventive and Remedial.

Preventive Treatment.—As most of the cases occur in fractures of the upper extremity in children, no bandages and dressings likely to cause constriction are to be placed on the part, especially if the fracture be about the elbow. We have elsewhere described how fractures in this region may be treated by putting the fore-arm in flexion and supination and suspending it in a sling. Whenever any circular dressing is applied to this part, proper allowance must be made for post-traumatic swelling. In any case, during the first 24 hours inspection and report is to be made at intervals of not less than four hours, and on the first complaint of pain or the appearance of swelling or discoloration of the fore-arm and hand the bandages are to be removed. The muscles should then be massaged, and the wrist and fingers moved, under an anæsthetic if need be, the fracture being steadied by an assistant. The limb below the fracture may be lightly bandaged so as to limit the effusion into the muscles. If needful, these procedures can be repeated until all danger of ischæmic contraction is past, and then the fracture can be attended to.

Remedial Treatment.—The success attending this form of treatment depends upon these elements—the length of time which has elapsed between the onset of the contracture, and the time at which treatment is begun, and upon the degree of involvement of the nerves. We have already described how we may ascertain if the nerves are damaged. If the latter is the case, we advise early operation and freeing the affected nerves from the pressure of scar or other tissue. Considerable success has attended such operations, provided that after-treatment has been vigorously and perseveringly carried out.

If the lesion is mainly muscular, we may elect to treat the case either by mechanical means, combined with vigorous massage, or by operation.

Physiological and Mechanical Treatment.—The parts are daily or twice a day bathed in hot water, massaged, then gently stretched, taking care to begin with the distal joints; and then unfolding each separately, while the proximal parts are held in the deformed position and treated mechanically in the following way:—

Acting on a suggestion from Mr. R. Jones, I have recently treated a case successfully in a boy aged twelve years, with a most advanced type of this affection, by the following method:—

A malleable iron splint of a suitable shape was fitted to the deformed limb, and the first step in the treatment was to obtain extension of the third phalanges on the second, and fix them thus for a week or so. When it was found that there was no tendency to contract, the process was repeated with the second and first phalanges, and then the wrist was gradually extended, and finally hyper-extended. During this time dry heat was applied to the hand twice daily for half an hour and the parts massaged. The boy recovered entirely in twelve months.

Mr. Jones[1] has carried out his treatment with some difference in detail. He "cuts out of zinc or sheet-iron five splints which

FIG. 568.

FIG. 569.

The Treatment of Ischæmic Paralysis. In Fig. 568 the Wrist is fully flexed, with the result that the flexion of the fingers disappears. In Fig. 569 a Zinc or a Sheet-Iron Splint has been applied separately to each extended finger (Robert Jones).

will fit the patient's fingers when extended. An assistant is asked fully to flex and to hold them forcibly and steadily in that position (Figs. 568, 569). By this manœuvre the fingers are relaxed, and each one must be separately splinted. The wrist is then relaxed, and the patient is asked to extend the now very contracted metacarpo-phalangeal joints. After a few days this can usually be done sufficiently to admit of splints being applied from the finger-tips to the wrist joint, the wrist being fully flexed to admit of this. The fingers are therefore bound in five splints, and over these the hand is fixed in a splint which reaches to the wrist (Figs. 570, 571, 572). For several days the hand is exercised in the direction of extension, and a splint applied over the other splints

[1] *Amer. Jour. of Orth. Surg.*, 1908, vol. v. pp. 377 *et seq.*

extending from the finger-tips to the elbow, and is at intervals altered, so that by degrees the wrist is fully extended. For some weeks this position is maintained until all contractural elasticity is lost. The splints are then removed and the hand massaged" (Figs. 573, 574, 575).

FIG. 570.

FIG. 571.

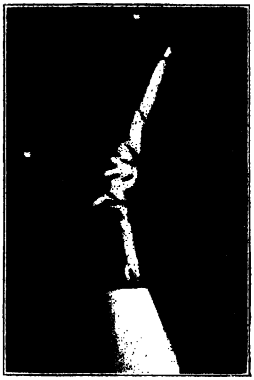


FIG. 572.

Continuation of Treatment of Ischaemic Paralysis; see text (Robert Jones).

The key-note of treatment is the gradual unfolding of each joint successively from the distal to the proximal; at the same time putting the joint or joints, immediately above those which are undergoing stretching, in such a position (generally of increased flexion) as will relax the strain upon the latter and therefore facilitate extension. Thus, a contracted finger can be extended a

few more degrees when the wrist is fully flexed, than when it is in the mid- or extended positions.

R. H. Sayre[1] speaks highly of this form of treatment and

FIG. 573.

FIG. 574.

After the Splints are removed the Fore-arm and Arm are Massaged. The Wrist and Fingers are seen in Voluntary Extension (Robert Jones).

quotes a successful case. In the next case which comes under my observation I intend, if no contra-indications are present, to try the systematic injection of fibrolysin, and a suggestion that

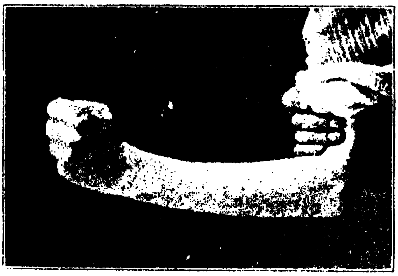


FIG. 575.—The Wrist and the Fingers are seen in Voluntary Flexion (Robert Jones).

may be of service is ionisation with Tr. Iodi. Whenever splints are fixed to the part, care must be taken not to compress the muscles; therefore, fixation should, as far as possible, be made over

[1] *Amer. Jour. of Orth. Surg.*, Nov. 1908, vol. vi. No. 2, p. 221.

bone and tendons. In carrying out physiological and mechanical treatment, great patience is required, and even if at the end of some months no improvement is seen, yet our efforts are not to be relaxed.

Operative Measures.—Stretching under an anæsthetic does not prove satisfactory. Tenotomy, subcutaneous or open, also tendon lengthening, have been tried with varying degrees of success, and the results have not been very promising. Resection of the bones of the fore-arm is advocated and carried out, but to us it does not appear that the improvement has been such as to raise any enthusiasm. This operation corrects the flexion deformity, but it weakens the extensors, and there is some danger of non-union of the bones, whilst frequently the usefulness of the hand is not increased.

Reviewing the pathology of the affection, it appears to us that of all operative procedures that carried out by Drehmann[1] is the most promising. The tissues of the fore-arm are laid bare, the main nerve trunks and the affected muscles dissected free from scar tissue, and the contracted muscles separated from each other and their neighbours. The affected muscles are then lengthened by crimping them on alternate sides, until the fingers can be fully extended. Their tendons are then divided at the wrist and sutured to the healthy tendons of a synergic group. In Drehmann's case marked improvement with good use of the hand, except the thumb, followed. This operation, although extensive, enables us to ascertain what the lesion is, where it is situated, permits us to remove fibrous tissue from around muscles and nerves, and is reconstructive owing to the tendon-grafting carried out. J. Jenks Thomas[2] has made an analysis of the results arrived at by all the methods of treatment, and the mechanical methods and tendon lengthening give the greatest number of improvements and success. Resection of bones is a feeble third. After any form of operation, passive and active movements, massage, faradic stimulation, and the usual physical therapeutics must be carried out sedulously, otherwise the effect of the operation will be to give a greater range of passive movement with no improvement in the functional use of the limb.

Chronic disease of the vessels, that is, angio-sclerosis, may lead to

[1] "Zur oper. Behandl. der isch. Muskelkontraktur," *Zentralbl. f. physikal. Therapie*, 1904-5, i. 257.

[2] *Ann. Surg.*, March 1909, pp. 330-370.

temporary interference with the nutrition of the muscles, so that "intermittent lameness"[1] results. This is of importance diagnostically, because such cases may run on to spontaneous gangrene. Further, the limping may, if the angio-sclerosis is overlooked, be the cause of an erroneous diagnosis—for example, intermittent limping is not uncommon in the very early stages of coxitis, and coxitis sometimes begins in adult life. According to Idelsohn, the younger the patient the worse the prognosis in lameness of vascular origin.

In some cases of atheroma, calcareous degeneration, obliterating arteritis, vascular obstruction by ligation, callus, or tumour, the atrophy of a part is again the effect of modified ischæmia. And so is the atrophy of the muscles sometimes seen after prolonged exposure to cold, that is, the wasting associated with frost-bite. Ischæmia, too, explains part of the atrophy met with in Raynaud's disease. The part that a localised ischæmia is believed to play in the production of congenital torticollis is fully explained elsewhere.[2]

Tuberculosis of Muscle

Primary tuberculosis of muscular tissue is a rarity, although the implication of a muscle from contact with a focus of osseous tubercle is not infrequent. This comparative immunity of muscle may possibly be due to the presence of antitoxin bodies in this tissue. As a matter of fact the adjective "primary" is, strictly speaking, incorrect, and in nearly all the recorded cases the muscular affection was obviously secondary to a primary focus elsewhere, such as in the lungs or intestine.

[1] Drehmann, "Intermittierendes Hinken eines Armes, der Zunge und der Beine," *Deutsche Zeitschr. f. Nervenheilkunde.* He suggests the term Dyskinesia or Akinesia intermittens angio-sklerotica. Kahn, "Über intermittierendes Hinken," Diss., Leipzig. 1905; "Obliterating Disease of the Vessels"; Muscat, "Das intermittierende Hinken als Vorstufe der spontanen Gangrän," *Sammlung klin. Vorträge,* Serie xv., Heft 19. Good bibliography appended. Idelsohn, "Weitere Beiträge zur Dysbasia angio-sclerotica (Intermittierendes Hinken)," *Deutsche Zeitschr. f. Nervenheilkunde,* Bd. xxxii., 1907; Gavazzeni, "La Claudicazione intermittente del midollo spinale," *La Clinica medica italiana,* Nr. 3, 1907.

[2] The literature of Ischæmic Contracture, Myositis, and Neuritis is now extensive. J. Jenks Thomas, *Ann. Surg.,* March 1909, pp. 367-370, gives no less than sixty-six references, alphabetically arranged, and the list is fairly complete. Alfred S. Taylor, *Ann. Surg.* vol. xlviii. pp. 407, 408, and A. H. Ferguson, *Ann. Surg.* vol. xlix. pp. 607, 608, supply shorter lists. R. H. Sayre, *Amer. Jour. Orth. Surg.* vol. vi. No. 2, Nov. 1908, pp. 231, 232, gives another list. The same references constantly reappear in the above; fresh ones are found in others. Yet, taken together, they are not complete, and one or two others appear in our text.

The muscles most frequently affected are those of the fore-arm, the biceps and triceps of the arm, and the quadriceps cruris. A solitary tuberculous focus may be present, and present any of the well-known stages of that process. It may be soft and gelatinous, caseating, or broken down, presenting the signs of a cold abscess. Multiple foci may exist in the same muscle, or the whole muscle may be infiltrated. At a later stage a cirrhotic change may ensue. More than one muscle may be affected, either simultaneously or at different times.

It is unnecessary to detail the symptoms, which depend on the character of the tumour present. The diagnosis from syphilis, lipoma, angioma, cysts, sarcoma, and muscular hernia, and from abscess due to non-tuberculous causes, may be a matter of great difficulty. Indeed, in some cases, without microscopical examination it may be impossible. The treatment consists of free removal. Possibly an entire muscle may require excision, and in that case its tendon should be attached to that of a muscle of its synergic group.

REFERENCES (after Ombrédanne)

* HABERMAAS. Beitr. z. klin. Chir., 1886, Bd. ii.
MÜLLER. *Ibid.*
* REVERDIN. Rev. méd. de la Suisse romande, 1891, No. 8.
* DELORME. Sem. méd., 1891, p. 152.
TRIA. Centralbl. f. allg. Path., 1892, Bd. iii. p. 457.
* LANTZ et DE QUERVAIN. Archiv f. klin. Chir., 1893, p. 97.
ROSENFELD. Diss. inaug., Königsberg, 1895.
* HÉMERY. Thèse de Paris, 1896-97.
* GROUT. Thèse de Paris, 1896-97.
GÉRARD. Gaz. des hôp., 1898.
* CORNET. Thèse de Paris, 1898-99.
ZIEGLER. Lehrbuch der spec. pathol. Anat., 1898.
MORESTIN. Bull. de la Soc. anat., 1896.
SALTYKOW. Centralbl. f. allg. Path. Bd. xiii.
* PLANTARD. Thèse de Paris, 1900-1901.
* ZELLER. Beitr. z. klin. Chir. Bd. xxxix. p. 633.
DURANTE, CORNIL, et RANVIER. Histologie pathologique, 1902, p. 359.
* LEJARS. Sem. méd., 1904, p. 169.
LE DENTU. Clinique chirurgicale, 1904, p. 223.
* FRIDA KAISER. Archiv f. klin. Chir., 1905, Bd. lxxvii. p. 1033, with bibliography (40 observations published).
ALGLAVE. Bull. de la Soc. anat., June 1906, p. 464.

* The asterisks indicate the more exhaustive articles.

MYOSITIS OSSIFICANS

Three types of myositis ossificans are recognised :—

A. Idiopathic, or myositis ossificans progressiva.

B. Myositis ossificans circumscripta, where the change is limited to one muscle, such as the brachialis anticus, or a group of muscles, such as the adductors, and the calf muscles.

C. Traumatic myositis ossificans, or osteoma of muscle and tendon.

A. MYOSITIS OSSIFICANS PROGRESSIVA

Myositis ossificans progressiva is a disease seldom met with, and fortunately so, since it is very intractable and steadily progresses to a fatal termination, in from ten to twenty years. It is characterised by a deposit of bone in the muscles, those of the back being, as a rule, the first affected. It is very rarely seen in the female sex, boys and young males being attacked.

FIG. 576.—Myositis Ossificans Progressiva (Michelson).

Pathology.—The pathology of the condition is in many ways still obscure. It is by no means certain that the designation is a correct one, since the general opinion is against an inflammatory origin. The muscle-parenchyma is not primarily affected, the bony deposit being interstitial. The fasciæ, ligaments, aponeuroses, and tendons are also affected. There may be simultaneously a periosteal development of bone, but this is not usual. Thus in a specimen in the Hunterian Museum the latissimus dorsi, the spinales, and rhomboid muscles are ossified, whilst bony outgrowths spring from the pelvis, ribs, and scapulæ.

The ætiology is unknown. Münchmeyer was of opinion that an interstitial myositis was the basis of the condition. Hawkins was in favour of a traumatic origin. Heredity and syphilis have also

PLATE XXXIV.

Radiogram of case in Fig. 576, showing Irregular Deposits of Bone (Michelson).

To face page 756.

been cited. There is much to be said in favour of the trophic hypothesis, which is supported by Hayem, Nicoladoni, and Eichhorst, and is analogous in some respects to morphœa or Addison's keloid.

Symptoms.—The affected muscles become at first tender, doughy, or brawny, and these signs are associated with neuralgia, or more frequently myalgia of a rheumatic-like character. It appears that this infiltration may subside and leave no trace behind, or repeated attacks of local swelling may occur before ossification becomes apparent. The muscles first and most generally affected are those of the back, especially the trapezius and latissimus dorsi. A characteristic attitude develops, the spine is slightly bowed and fixed more or less, and the chin is bent forward on the sternum. Abduction of the arms is interfered with, and if the masseters are affected, as is often the case, the jaw is fixed. Irregular bosses of bone may become obvious, at first about the scapular and interscapular regions, and then the erector spinæ becomes involved, particularly in the lumbar region (Fig. 577). Finally other regions of the body and the limbs are attacked. Thus in Cæsar Hawkins's case, the progress of which was watched for nineteen years, at a late stage the pectorales majores were almost entirely ossified, and the sterno-hyoid and sterno-thyroid muscles considerably so, causing much trouble in deglutition.

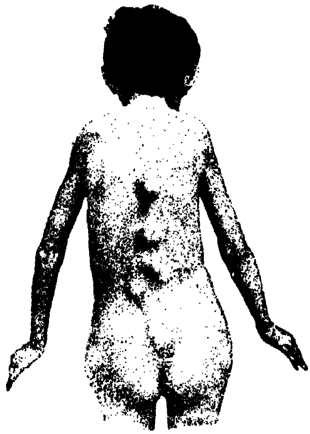


FIG. 577.—Back view of a boy the subject of Diffuse Myositis Ossificans (Kümmel).

The ribs become fixed, partly by ankylosis and partly by ossification of the muscles. Breathing becomes diaphragmatic, and the fatal termination is generally due to intercurrent respiratory diseases. The fixation of the jaw may necessitate artificial feeding, and ulceration over the prominent bosses calls for appropriate measures.

A frequent and striking coincidence in the recorded cases is a peculiar congenital deformity of the metatarso-phalangeal joints of the toes, the articulation being displaced inward, and the great toe outward. Nové-Josserand[1] has noticed this deformity, together with

[1] Nové-Josserand and René Horand, *Rev. d'orth.*, March 1, 1905.

thickening of the first metatarsal bone and shortening of the great toe. In the hands, the third phalanges of the little fingers are inclined outward, and the first metacarpals are thickened.

Treatment.—Curative treatment has so far failed. Mercury, iodide of potassium, phosphoric acid, hydrochloric acid have all been tried with disappointing results.

REFERENCES

CÆSAR HAWKINS. Med. Gaz., 1844, vol. xxxiv. p. 273.
T. SYMPSON. Clin. Soc. Trans. xix. 315.
J. RICKMAN GODLEE. Clin. Soc. Trans. xix. 333; also cf. Clin. Soc. Trans. vol. xxix. p. 221, vol. xxx. p. 245.
PÉHU et HORAND. Gaz. des hôp., 1905, No. 140. With bibliography up to 1905.
DE WITT. Am. Jour. Med. Sci. vol. cxx. p. 295, with bibliography, also a very complete list of references from the article by Nové-Josserand and René Horand, Rev. d'orth., March 1, 1905, pp. 241-243.

B. AND *C.* MYOSITIS OSSIFICANS CIRCUMSCRIPTA AND TRAUMATIC MYOSITIS OSSIFICANS

Synonyms—English, *Osteoma of Muscle and Tendon*; French, *Ostéomes des cavaliers, Ostéomes des fantassins* (*Larrey*), *Myostéomes traumatiques* (*Cahier*), *Arrachements périostiques, Désinsertions musculaires, Myosite ossifiante localisée, Myosite ossifiante traumatique*; German, *Reiterknocken* (*Billroth*).

Definition.—An affection in which masses of bony tissue of varying sizes develop within or in contact with the muscles, often following traumatism.

The large number of synonyms shows that those who have written upon it are not clear as to the identity of the affection, nor whether under the term "osteomata of muscle and tendon" one or several affections are included.

History.—Early observations on the affection were made by Mascarel, Demarquay, Barth, and Gillette. In 1825[1] Abernethy mentioned the case of a lad in whom a bony growth in a muscle invariably followed a blow upon it. Since his time, Billroth in 1855, Virchow, Volkmann, and particularly Josephson in 1874, published memoirs dealing with the affection. Since 1874[2] the

[1] Abernethy, "Surgical Lecture III.," *Lancet*, April 1825.

[2] "Myositis Ossificans," C. F. Painter and John D. Clarke, *Amer. Jour. Orth. Surg.* vol. vi., May 1909, p. 626.

PLATE XXXV.

Radiogram of part of the upper limb, showing Myositis Ossificans, secondary to Dislocation of the Elbow (Ombrédanne).

To face page 759.

observations have been more frequent. Cahier[1] assembled notes of 133 cases, whilst many records are found in German surgical works. R. Jones and D. Morgan in an illustrated communication[2] added 20 reported cases to those collected by Cahier, and give 26 X-ray and other illustrations.

Ætiology.—The bony formations occur chiefly in males; of Cahier's 133 cases only 6 were in women. The usual age is between twenty and thirty years, and the fact that soldiers and horsemen are chiefly affected suggests a causative element of traumatism The brachialis anticus is affected as often as any other muscle[3] (45 cases), then the adductors of the thigh (40 cases), the quadriceps femoris, 28 cases; and, exceptionally, the biceps cubitis, supinator longus, pectineus, gluteus maximus, the hamstrings, and very rarely the temporals. It is said that gonorrhœa may be a predisposing cause, but the usual history is that of traumatism, either single and severe, or slight but often repeated.

Pathology.—I. Some of the new growths (traumatic type) are distinctly connected with the bones, especially those near the elbow-joint, and follow a dislocation (Plate XXXV.). A small piece of periosteum is stripped up and implanted among the torn muscular fibres and develops bone. Experimentally Berthier was able, by detaching small portions of periosteum at the muscle insertions, and electrically stimulating the muscle, to induce development of small pieces of bone in the interior of the muscle-sheath. Other examples of the periosteal detachment type are those exostoses which develop along the posterior aspect of the tibia about the origins of the tibialis posticus and the flexor profundus digitorum due to *pas de parade* (Toussaint).

II. The next group is quite different. They may be spoken of as muscular osteomata proper. When multiple, they often number four or five, and are disseminated in the mass of the muscle itself (Plate XXXVI.). In shape they may be rounded, lamellar, or like a lobster's claw. While some are unconnected with the skeleton, yet others have a pedicle, running along the tendon or quite independent of it, and are attached to the bone. So that we meet with tendinous, intermusculo-tendinous, aponeurotic, and inter-musculo-aponeurotic deposits. As a rule the plate-like formations

[1] *Rev. de chir.*, 1904, pp. 356, 602, 768, 826.

[2] *Archives of Röntgen Ray and allied Phenomena*, 1905 and 1906.

[3] Formerly Prussian soldiers repeatedly brought the musket sharply up against the deltoid in drill exercise, and the result was the formation of the so-called "drill-bone" (Holmes).

are on the surface of a muscle, and the rounded or oval ones in the interior. The growths, when early, are transparent to X-rays, but later arrest their passage.

The bulk of pathological opinion supports the view that these growths have no apparent connection with the skeleton. At certain points endochondral ossification is seen, the cartilage appearing to arise from the transformation of surrounding connective tissue

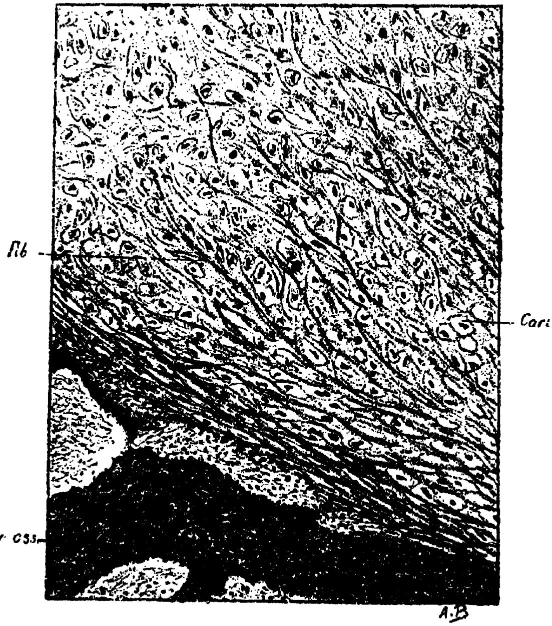


FIG. 578.—Microscopical Section from a Muscular Osteoma (Myositis Ossificans, Lecène). *tr. oss.*, New Bone Formation, identical in Structure with Normal Bone ; *Cart.*, Cartilage, which is either Fibro-Cartilage or Hyaline ; *Fib.*, Fibrous Tissue with Cartilage Cells between the Bundles. The Fibrous Tissue is continuous with the Muscular Substance (not shown) (Ombrédanne).

(Fig. 578). At other points the process seems metaplastic (like the periosteal form) without the intervention of cartilage.

The pathological theories of the origin of these growths are numerous. According to Bard they are sesamoid bones, and his view is supported by Pincus. Other observers, such as Orlow, Berger, Sieur, Reynier, Berthier, Berndt, and Schultz, favour the theory of "periosteal insemination." This theory may be correct in the "periosteal detachment" cases, but does not account for the intra-muscular cases. Berndt, however, suggests that the periosteum

PLATE XXXVI.

Skiagram of the thigh of a female, aged 18 years, who developed Traumatic Myositis Ossificans, affecting the Sub-Crureus Muscle.

To face page 74.

is torn and the osteogenetic cells escape. Experiments on animals in support of this theory have been made by Ollier, Langenbeck, Cornil, Coudray, Sieur, and Berthier. There are certain points, however, which militate against the periosteal insemination theory, and these are—

a. At that part of the bone where the tendon is inserted the periosteum is absent.

β. No account is taken in the experiments of the effects of hæmatoma and fatigue.

γ. When tendons are affected, there is no explanation forthcoming as to the manner in which osteoblasts can penetrate dense tendons.

δ. Osteomata of muscle are never seen after the use of the rugine, when it is forcibly employed to separate muscle and strip off the underlying periosteum from the bone.

A third theory is that these forms of myositis ossificans are due to transformed hæmatoma. This theory was advanced by Seydeler and upheld by Charcot, Demmler, Nimier, Ramonet, and Auregan. An objection has been raised that blood clot cannot transform into bone, but this is formal only. The clot can be and is at times replaced by young proliferating cells which become the precursors of osseous tissue (Zhuber, von Okrog, Rammstedt, and Mignon).

Finally, Haga and Fujimura have recently stated that myositis ossificans has followed experimental contusions and ruptures purely muscular.

Ombrédanne sums up the whole question thus:—"A certain number are of periosteal origin. We must also grant the possibility of the transformation of other mesoblastic tissues into bone; and further, the provisional callus, preliminary to the deposit of bone, may be derived from the transformation of a hæmatoma, or the cellular proliferation following on rupture of muscle." Moreover, we must not overlook Arbuthnot Lane's view that ossification in unusual situations may follow excessive strain on muscles, ligaments, and bones.

Course and Symptoms.—In the circumscribed form, such as arises from irritation, the onset is very slow, whilst in the traumatic form complete transformation of a muscle may take place very rapidly. I have seen the subcrureus on two occasions become completely ossified in three months as the result of blows on the lower part of the thighs. The onset of the traumatic form may be suspected if, after an injury, particularly after a dislocation, the range of move-

ment becomes more and more limited, and an unusual thickening is felt over the bone in the situation of one or more of the muscles. Röntgen-rays give the clearest indications of the presence of these tumours, of whatever origin they may be.

Treatment of the circumscribed and traumatic forms is surrounded by considerable difficulty. Massage favours their growth, and in a sense this is desirable, because no operation can be successfully undertaken until the osteoma, like a cataract, is ripe, *i.e.* until the whole of the affected muscle is transformed into bone. If on account of danger to the mobility of a joint an early operation be done, care must be taken to remove all the muscle and its sheath and the new bone with it. If a pedicle exists, this is divided, and its base is cut freely away with a ring of the periosteum around it. After an operation, passive movements of the parts are undesirable, and massage is to be deprecated.

Other Forms of Myositis.—These are—

(*a*) Acute polymyositis.
(*b*) Hæmorrhagic myositis.
(*c*) Myositis which accompanies urticaria and erythema.
(*d*) Neuro-myositis.
(*e*) Myositis due to trichina.

These forms are not of immediate interest to the surgeon, and are not within the scope of this work. A graphic description by Dr. F. E. Batten is found in *Encyclopædia Medica*, vol. viii. pp. 183 *et seq.*

New Growths in Muscle

The primary forms are rare. Sarcomata, fibro-sarcomata, and myxo-sarcomata are the most usual. Rare forms are fibromata, lipomata, angeiomata, myxomata, and enchondromata. Any secondary growth may be found in muscle. A few cases of that very rare disease, rhabdomyomata, have been recorded, and hydatids are met with, particularly in Australia.

Hernia of Muscle

Definition.—Hernia of muscle is a tumour formed by the projection of a portion of that structure—healthy, intact, and not ruptured—through its aponeurotic sheath.

True hernia is to be distinguished from the "pseudo-hernia" of Farabeuf (see "Rupture of Muscle").

Ætiology.—It is met with in adult males, and is usually traumatic in origin. Pichon examined 217 Alpine chasseurs, and 39 had muscular hernia of the tibialis anticus, the existence of the lesion not having been suspected. Long-fibred muscles, such as the tibialis anticus, the adductor longus, the rectus femoris, the biceps brachialis, are usually affected.

Pathology.—The projection almost always takes place through a button-hole in the sheath. Occasionally the sheath may be thinned at one spot without its continuity being destroyed, and then the muscle raises it and makes a prominence. The tumour appears when the muscle is at rest, and disappears when contraction occurs.

We have stated that trauma, such as contusions and strains, is the usual cause, but some cases are due to ulceration of the sheath from suppuration or from syphilitic destruction, and others follow surgical operations, when the sheath is not carefully sutured. A very few are due to congenital deficiency of the sheath. Guimard has experimentally produced the condition by excising a portion of the sheath of the semimembranosus in rabbits.

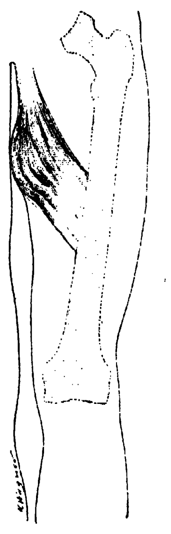


FIG. 579. — Muscular Hernia, the Muscle being in Repose (Ombrédanne).

Symptoms.—The swelling varies in size from an olive to a hen's egg, but it is usually quite small. It is soft, semi-fluctuating, never pedunculated, depressible and reducible, and after reduction the margins of the aperture in the sheath or the aponeurosis can be easily defined. It is evident only during relaxation of the muscle (Fig. 579). When contraction begins the tumour hardens somewhat and gradually diminishes (Fig. 580), and completely disappears during resisted contraction (Fig. 581). Farabeuf says that "any tumour which fails to disappear when a muscle is passively stretched or actively contracted is not a (true)[1] muscular hernia." We dwell on the epithet "true," because to Farabeuf is largely due the confusion which has arisen from the introduction of the term "pseudohernia," which is always associated with rupture of the muscle, partial or complete.

[1] Word in brackets is inserted by the author.

Treatment.—The only method is by operation, and even this is not strikingly successful. The sheath is exposed, the edges of the aperture are freshened, the protruding portion of the muscle is

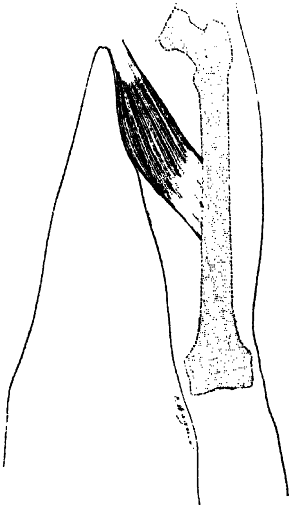


FIG. 580.—Muscular Hernia, the Muscle being in Contraction (Ombrédanne).

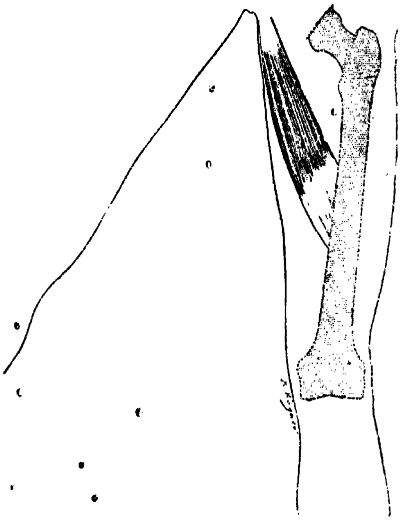


FIG. 581.—A Muscular Hernia, the Muscle being Passively Stretched (Ombrédanne).

cut away, and the aperture carefully sutured, care being taken to overlap the edges. Recurrences, however, are not infrequent.

REFERENCES

FARABEUF. Bull. de la Soc. de chir., 1881.
NIMIER. Arch. gén. de méd., 1882, vol. x. p. 285.
GUIMARD. Gaz. hebd. de méd. et de chir., 1888, p. 214.
NIMIER. Merc. méd., 20 janvier 1892.
GAZIN. Arch. de méd. milit., 1892, p. 310.
TEDENAT. Montpellier médical, 1892, p. 148.
HARTMANN. Rev. de chir., 1893, p. 508.
CHOUX. Rev. de chir., 1893, p. 485.
MORANGE. Thèse de Paris, 1893-94.
MICHAUX. Bull. de la Soc. de chir., 1894, p. 711.
LEGUEU. Cong. de chir., 1895, p. 699.
FÉRÉ. Rev. de chir., 1900, p. 450.
STEUDEL. Beitr. z. klin. Chir., 1902, Bd. xxxiv. p. 611.
FÉRÉ. Rev. de chir., 1905, p. 339.
CAHIER. Arch. de méd. et de phar. milit., janvier 1903, p. 23.
PICHON. Arch. de méd. et de phar. milit., 1906, p. 471.

Congenital Absence of Muscle

A few cases of this rare condition are reported, and generally the pectoralis major of one side has been absent, with flattening and depression of the chest wall on that side, and an unusual thinning of the anterior axillary fold. It has been observed that the arteries on that side of the trunk are abnormally small. Occasionally the latissimus dorsi and the pectoralis minor are deficient as well. Absence of some of the abdominal muscles and of the semi-membranosus has also been described. The condition of the ventral muscles in ectopia vesicæ is familiar to surgeons. Occasionally a part of a muscle is absent, *e.g.* the lower part of the pectoralis major is wanting, while the clavicular portion is well developed. When a bone is absent, such as the fibula or radius, some of the muscles are not developed or are merely represented by fibrous cords. The interest of muscular deficiency is mostly anatomical, except in so far as deformity may arise from it, and the absence of muscle does not necessarily cause any loss of function, as that is assumed by one or more of the synergic group. This fact is of importance in appraising the value of tendon and muscle grafting.

Atrophy from Disuse. Tropho-Neurotic Atrophy

It is well known that if a part is not functionally active, a general atrophy, involving not only the muscle, but all the structures, supervenes. We shall deal here with atrophy of the muscles only. That simple atrophy from disuse occurs is evident from the fact that when a patient is laid up with an injury to one knee, the extensors of both limbs waste. And this is borne out by the experiments of Bum,[1] where both hind legs of dogs were immobilised and an arthritis set up in one of the joints of one leg. Pieces of muscle excised after six to eight days' fixation showed degenerative processes equally marked in both limbs. The fixation then causes the atrophy, the inflamed joint being only an element of auto-fixation. Experiments on animals, then, are in favour of the theory of simple atrophy from disuse rather than from a tropho-neurosis.[2] Further, two clinical facts are against the tropho-neurotic theory. First, the very early onset of the muscular degeneration; second

[1] Bum, "Über arthritische Muskelatrophie," *Wiener med. Presse*, 1906, xlvii. 51.
[2] Bum, Naturforscher- und Ärzteversammlung in Meran, September 1905.

that while the amount of atrophy seems to bear no relation to the severity of the arthritic disease, it does seem to be quantitatively related to the degree of immobilisation present. Still the reflex or trophic theory is supported by such great names as Vulpian, Paget, and Charcot, and it has many points in its favour. There is also the experimental evidence contributed by Raymond and Deroche, who stated that after division of the nerve-roots the usual atrophy of disease failed to appear. It is obviously, however, difficult to interpret the results of such an experiment, since we have no means of estimating in set terms the effects of disuse, of the experimental joint disease, and the effect of nerve section. It would take us too far to attempt to criticise the findings from a neurological standpoint, and on the whole we agree with Bum that whilst the expression "atrophy from disuse" is clinically justifiable, still reflex disturbances cannot be altogether disregarded.

Idiopathic Muscular Atrophy and Hypertrophy

These affections are grouped under the title of "myopathies." We may classify them as follows—

1. The Infantile Type—in which there is a progressive atrophy of the muscles of the trunk and limb.

2. The Erb or Juvenile Type—an atrophy chiefly affecting the muscles of the arms, shoulder, and pelvic girdle.

3. The Facio-Scapulo-Humeral Type or Landouzy-Déjerine Type—in which, as the name implies, the muscles of the face, shoulder, girdle, and arms are involved.

4. The Peroneal or Charcot-Marie-Tooth Type—in which the muscles of the legs, particularly the peronei, of the fore-arms, and back become atrophied.

5. An Hereditary Form of Progressive Muscular Atrophy in young children.

6. The Pseudo-Hypertrophic Type—a well-known form of myopathy.

It is not necessary to go into elaborate detail of the distinctive points of these affections, but they will be dealt with in so far as they interest the orthopaedic surgeon, in the section treating of "Paralytic Deformities."

Thomsen's Disease

This affection was described in 1876 by Thomsen, himself a sufferer from it. It is both congenital and hereditary, and is characterised by marked hypertrophy of the muscular fibres and proliferation of the nuclei. A certain amount of paresis is always associated with it.

The chief symptom is a peculiar rigidity of the muscles occurring after they have been at rest for some time, and they become "unlimbered" by use. Thus, the movements are free at the end of a long walk, but a night's rest is followed by hardness of the muscles in the morning.

CHAPTER II

INJURIES AND DISEASES OF TENDONS AND THEIR SHEATHS

Accidental Division—Suturing and Restoration of Tendons—Rupture—Luxation of Tendons—Teno-Synovitis and Teno-Cellulitis, Traumatic, Infective, Dry or Crepitant, Serous, Suppurative—Results of Teno-Synovitis, Jerk-Finger—Proliferating Teno-Synovitis—Arborescent Lipoma of the Tendon-Sheaths—Teno-Synovial Cysts—Simple Ganglion—Rheumatic and Gouty Teno-Synovitis—Tendinitis—Tuberculous Teno-Synovitis—Gonorrhœal and Syphilitic Teno-Synovitis—New Growths of Tendons and their Sheaths.

ACCIDENTAL division is the most frequent and important injury, and the majority of cases are due to cuts about the wrist and hand.

Symptoms.—Section of a tendon does not always lead, as we might expect, to the position arising from the uncontrolled action of its antagonist. Thus, if the extensor tendon of a finger is divided, the digit becomes moderately but not fully flexed, the flexors concerned being, as it were, instinctively thrown out of action, so that the gap caused by the retraction of the cut tendon is not at first increased.

We must not rely upon the position of the member as a sign of division, but the fact that that movement which is normally performed by the injured tendon, or rather muscle-tendon, can no longer be carried out. The only doubtful point which may crop up in certain cases is whether the disability is due to division of a tendon, or to paralysis from section of a motor nerve. This can be decided by electrical stimulation of the body of the muscle from which the tendon arises. If it is seen that on contraction of the muscular belly the appropriate movement of the part into which the tendon is inserted does not follow, then we are correct in saying that the tendon is divided.

Anatomy.—A certain amount of "tonic" contraction of muscle is normally present, otherwise time would be lost in taking up the "slack" before useful contraction set in. When a tendon is cut, this

tonic contraction causes retraction of the proximal end. This is further aided by the reflex muscular contractions set up by the injury itself, and perhaps by the muscle taking part in contractions of its synergic group. Howsoever the subsidiary causes may affect the question of retraction, the tonicity or elasticity of the muscle leads to considerable displacement of the proximal end. It usually disappears entirely from the wound—indeed in some cases, for example, the extensor tendons of the thumb, retraction of $2\frac{1}{2}$, 3, or even more inches has been observed. On the other hand, retraction may be more or less successfully resisted by aponeurotic expansions of the tendon; or, in the case of those muscles which have several tendons, some of them remain intact and keep the belly on the stretch; or on account of the anatomical arrangement of the sheaths, as in the case of the index, middle, and ring fingers, when the tendons are steadied by the vincula accessoria tendinum. Further, the site of the injury is of importance. Flexor tendons divided in the palm retract but little. If the division is above the wrist, the proximal end retracts greatly.

The intrinsic retraction of the distal fragment is nil. It may disappear from the wound, but this is merely due to the position of the part. If we replace it in the position it was in when the injury was received, the cut end re-appears.

In practice, especially in lacerated wounds, it may be difficult to distinguish between the cut end of a tendon and a divided nerve. The latter, however, retracts less than a tendon; and stimulation, mechanical or otherwise, of what appears to be the nerve cord soon settles the question. Writing on the "Functional Prognosis of Tendon Suture," Dr. Wolter[1] discusses the probabilities of good union with or without suture according to the tendon affected.

It is possible here to summarise merely the main points.

The Extensor Tendons of the Hands.—If these be divided, better results may be expected than in the case of the flexors, since less retraction follows, owing to their closer attachment to the sheaths, to the integument, and to one another. However, the retraction is greater when division occurs above the wrist than below it.

Extensors of the Thumb when divided at the Back of the Wrist.—Retraction in this situation is about 1 cm., owing to the tendon and its sheath being more or less bound down by periosteum. When division occurs over the metacarpal bone, the central end will retract as much as 10 cm., since the tendons play freely in the sheath, and

[1] *Archiv für klin. Chir.* Bd. xxxvii. Heft 1, and *Ann. Surg.* vol. ix. p. 55.

the latter is very loosely attached to surrounding structures. At the metacarpo-phalangeal articulations the prognosis is especially good, as the tendons are bound down to the capsule of the joint, and cannot retract even though the joint has been opened.

Flexor Tendons at the Wrist-Joint.—The slightest shortening of these tendons interferes with extension of the hands and fingers; for it is known that on the strongest extension, the flexor tendons which follow the excursion of the bones are stretched *ad maxima* and lie close to the bone, so that their length just suffices. Extension will be hindered by the slightest adhesion between the cicatrix of the flexor tendons and the skin; and still worse is it when several flexor tendons are matted together in a dense scar. At the wrist two fasciæ are found, the superficial of which is strongly attached to the surface of the flexor carpi ulnaris, and partly assists in forming sheaths for the tendon of the palmaris longus and the flexor carpi radialis; the second or strong deep fascia binds down the remaining flexor tendons and the vessels. Therefore after division of the tendons of the flexor carpi radialis, flexor ulnaris, and palmaris longus, the cicatricial process is isolated and takes place above the deeper fascia, and the prognosis will be much better than if the deeper tendons are severed. The tendon of the palmaris longus retracts $\frac{1}{2}$ inch when divided at the wrist, and that of the flexor carpi radialis nearly an inch. These measurements are obtained by ascertaining the excursion made by the tendons at that spot in passing from dorsal to palmar flexion.

Tendons divided in the Palm of the Hand.—The results here are more favourable than at the wrist-joint. The retraction of the sublimis is a little more than $\frac{1}{2}$ inch, and of the profundus a little less.

Flexor Tendons divided over the Phalanges.—The central end retracts slightly on account of the vinculæ. Most retraction takes place over the first phalanx and at the base of the second; as much as $\frac{1}{3}$ inch occurs. The prognosis for tendon-suture in the region of the first phalanx is better than at the other phalanges.

Tendons divided on the Dorsum of the Foot.—The prognosis here is good. Two cases are quoted by Wolter, and as a matter of clinical experience we know that union is good, although retraction to as much as $1\frac{1}{4}$ inch usually occurs.

Section of the Tendo Achillis.—If division takes place less than 1 inch from its insertion, in adults, there is but little separation of

the divided ends, and the heel may still be slightly raised. If division occurs above this point there is a gap of over 1 inch.

In performing operations for restoring the continuity of severed tendons the points brought forward by Dr. Wolter should be borne in mind.

Union of tendon.—Once destroyed, true tendon material is not reformed. Union is by the intervention of a fibrous cicatrix, which itself originates from the organisation of a provisional callus. The origin of the cells forming this callus is a subject of dispute. In this connection the author's experimental work and conclusions may be of assistance.[1]

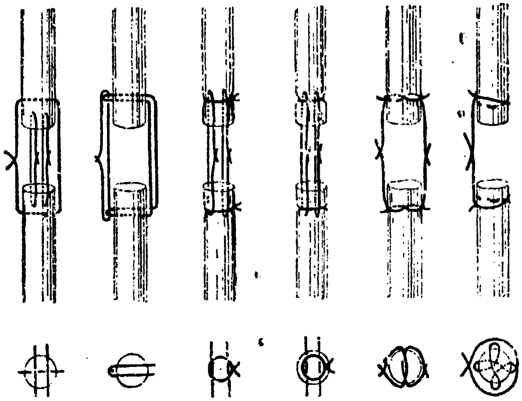
Treatment.—The continuity of the tendon must be restored, and with rare exceptions this is only possible by means of suturing the cut ends together. One great advantage of operative interference is that opportunity is afforded for thorough cleansing and disinfection of the wound. Suppuration in a tendon sheath is readily evoked, and the tendon itself has such a low vitality and poor blood-supply that it very easily sloughs and exfoliates. The importance of reducing the probability of infection to a minimum is therefore obvious. Even modified inflammatory reaction is to be deprecated on account of the excess of cell proliferation and subsequent adhesions to the sheath or the skin, with ultimate restriction of movement. Cicatrices thus formed are not only often painful, but are liable to late, even very late suppuration when movement is permitted.

The wound having been thoroughly cleansed and all hæmorrhage arrested, the cut ends are secured. There is little difficulty with the distal end; thus, if a flexor is cut, flex the part; if an extensor, extend, and the end appears. To find the proximal end is quite another matter. It may be, as it were, squeezed into view by the application of the Esmarch's bandage, or brought down by pressure from above. A useful manœuvre is to put the neighbouring muscles on the stretch, as suggested by Félizet. Thus if the flexor of the middle finger is cut, possibly the upper end may be brought into view by hyper-extending the ring and index fingers, and the cut tendon insinuates itself along the sheath as the intact tendons of the remaining portion of the flexor muscle are stretched. As a last resource a dissection must be made, the tendon sheath being followed up, after inserting a probe.

As to the method of suture we use a needle with a non-

[1] *Guy's Hospital Rep.*, vol. xlix. p. 109, Art. "Regeneration of Fibrous Tissue."

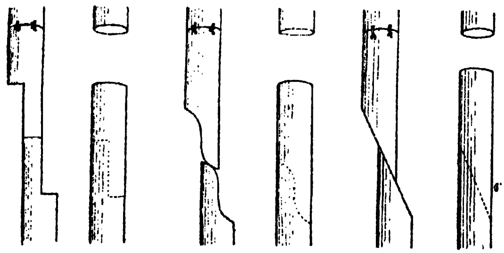
cutting edge, and materials capable of absorption. Most surgeons prefer fine catgut lasting ten to twenty days before it disintegrates. As tendon splits longitudinally so readily, some method must be adopted to prevent this, or else as soon as traction is put on the part the sutures will pull out.



Le Dentu. Trinka. Ed. Schwartz. Gangolphe. Von Arx. Suter.

FIG. 582.—Methods of Suturing Severed Tendons (Ombrédanne).

For rounded tendons Schwartz's procedure is the best. He ties a constricting ligature about a quarter of an inch above the cut end, and then applies the uniting sutures as in Fig. 582. The object of this device is obvious. For oval or flat tendons the



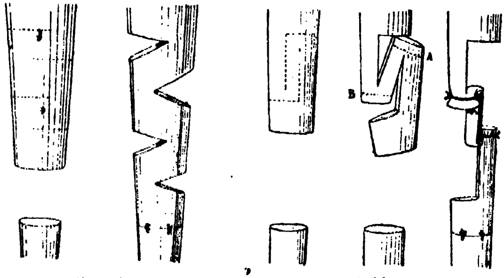
Rabere. Prioleau. Boyer.

FIG. 583.—Methods of Elongating Tendons (Ombrédanne).

method of Von Arx is advised by Ombrédanne. Von Arx instead of one circular ligature, threads each of the tendon ends with a double interlocking thread (see Fig. 582); then he ties the free ends together, thus securing as much co-aptation of the tendon ends as possible.

When the tendon ends cannot be brought sufficiently close together, one of several procedures may be adopted.

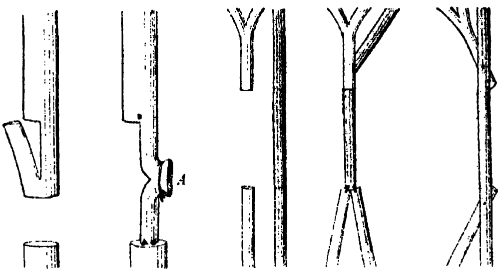
A. (i.) The tendon may be lengthened by a process involving a double section, Fig. 583. We cannot advise this as a routine procedure, for if there is the slightest degree of sepsis present the



Poncet. Hibbs.

FIG. 584.—Methods of Elongating Tendons (Ombrédanne).

separate piece of tendon will infallibly slough; neither is it safe where the tendon passes through an osseo-aponeurotic groove, and the blood-supply to the sheath is feeble.



Czerny. Procédé Modifié. Rochet. Double Anastomosis.

FIG. 585.—Methods of Elongating Tendons (Ombrédanne).

(ii.) An autoplastic procedure may be adopted, in which the tendon to be lengthened is not completely divided (Fig. 584). The method of Poncet is simple and gives a fair amount of lengthening. That of Hibbs is a little more complicated, but as a compensation much greater lengthening is obtainable. To prevent splitting, ligatures must be applied at A and B.[1]

[1] David Silver, *Amer. Jour. Orth. Surg.*, 1907, vol. iv. No. 3, p. 218 *et seq.* "An Experimental Study of the Influence of Necrosis produced by Sutures in Tendon Suture and Transplantation," has shown that necrosis of the tendon end does not occur if the sutures are tied under ordinary tension.

(iii.) A simpler method than Hibbs' is that of Czerny, in which the lengthening is obtained by splitting the required length of the tendon, and reversing it as in Fig. 585. Provided the precaution is taken to encircle the point A with a ligature the method is a good one.

(iv.) Autoplasty by double anastomosis. This has been fully dealt with elsewhere in vol. ii. sect. x.

(v.) Heteroplastic operations in which tendon from another animal is introduced into the gap have not been successful, as the grafts either separate or become absorbed.

(vi.) The junction may be effected by means of a foreign body. Mercurialised silk is most generally and successfully used. Catgut, silver wire, a tube of osseine, a tube of gelatine hardened in formol have all been tried. We have had many striking successes with the new silk method and we append notes of a few cases.

CASE 24.—*Severed Extensor Tendon of Index Finger, with a Gap of One and Three-quarters Inches replaced by Silk.*—Edith W., aged 14 years, was seen by me at Westminster Hospital in January 30, 1906. Five months previously she cut the dorsal surface of the second phalanx of the right index finger. The wound healed, but the finger has been flexed since that time. The finger was gradually extended, and then hyper-extended by an adjustable malleable iron splint. On February 1, 1906, an incision was made on the dorsum of the finger from the metacarpo-phalangeal joint to the base of the third phalanx, and the ends of the tendon found to be separated, when the finger was fully extended, by a gap of $1\frac{3}{4}$ inches. A double strand of No. 3 mercurialised silk was inserted so as to bridge the gap. At the upper end the silk was passed through the proximal end of the tendon; and at its lower end it was anchored to the base of the third phalanx. In six weeks' time complete power of extension had been restored to the finger.

A much bolder and partially successful operation was the following, undertaken for complete crippling of the hand after septic infection:—

CASE 25.—*Complete Loss of the Flexor and Tendons in the Palm of the Hand, Insertion of Mercurialised Silk Tendons.*—A nurse was sent to me with the left hand completely crippled. The wrist was flexed, and movement was nearly lost in the fingers and in the thumb. The only movements left in the fingers were due to the action of the interossei muscles. The operation undertaken proved to be very tedious and difficult. An incision was made from 3 inches above the wrist nearly to the root of the middle finger. The median nerve lying in scar-tissue was isolated after much trouble. The long tendon of the thumb was destroyed for a distance of 3 inches, in those of the index finger the gap was $2\frac{1}{2}$ inches,

in those of the middle and ring fingers a little over 2 inches, and in that of the little finger 3½ inches. The tendons terminated above in a dense mass of scar-tissue, and below the ends were adherent to the bones. The ends were separated and refreshed, and two strands of No. 3 mercurialised silk were used to connect the tendon ends.

The result three years afterwards is that the wrist can be voluntarily flexed to 90° and extended 35°. Flexion to 60° is possible at the first metacarpo-phalangeal articulation, but extension is very limited. There is partial voluntary movement of the first interphalangeal joints of the fingers, and of the second joints of the 2nd, 3rd, and 4th fingers to 70°, and of the 5th finger to 10°. The thumb can be flexed to 60°. The result is thus partially successful, but it has been discounted by the stiffness and fibrous ankylosis of the small joints, which limits the full movements of the fingers, and by the tendency of the artificial tendons to adhere to the scars in the palm, resulting from the incisions, made for the exit of pus when the whitlows were treated. The patient can, however, play some piano exercises with the four fingers.

(vii.) Interposition of neighbouring soft parts. Mollière has interposed a layer of peritendinous connective tissue. However, on account of adhesions this is rarely successful. Ombrédanne gives the preference, amidst all these procedures, to the process of Czerny, that is splitting and turning down the tendon, combined with annular ligature to prevent complete separation (Fig. 585). We prefer the insertion of mercurialised silk, which ultimately constitutes the axis of a new tendon (see vol. ii. sect. x.).

B. In certain cases it may be possible to approximate the insertion of the muscle to its origin (Poncet). Thus the level of the tubercle of the tibia or of the insertion of the Achillis may be altered by detaching it with a saw and refixing higher up.

C. Shortening of the bones of the limb (Löbker). It is very rare that conditions arise, which render this procedure necessary or advisable.

D. Finally we may renounce direct suture altogether and join the cut ends to neighbouring tendons.

We have now considered—

1. The method of uniting the cut ends.
2. Of lengthening the tendon if necessary.
3. It may be, however, that one has failed to find the proximal cut end. In this case the best plan is to anastomose the distal end to the tendon of some neighbouring muscle, the action of which is most advantageous under the circumstances.

Missa in 1770 was the first to do this. The communications of Tillaux, Polaillon, Le Fort Duplay to La Société de Chirurgie in

1875 first brought the operation into current practice. Nicoladoni in 1881 utilised it in infantile paralysis.

The methods employed are seen in Fig. 586. To prevent adhesions to the skin the reconstituted tendon must be covered with a sheath of connective tissue. It is important to preserve the synovial sheaths as much as possible.

The *after-treatment* is all important, and everything depends upon the position in which the part is placed immediately after the operation, how long it is immobilised, and how long partially so. Experience alone can decide in each case.

After any form of tendon suture it is necessary so to place the part, for example the finger, in such a position that there is no strain or tension upon the tendon which has been sutured. Thus,

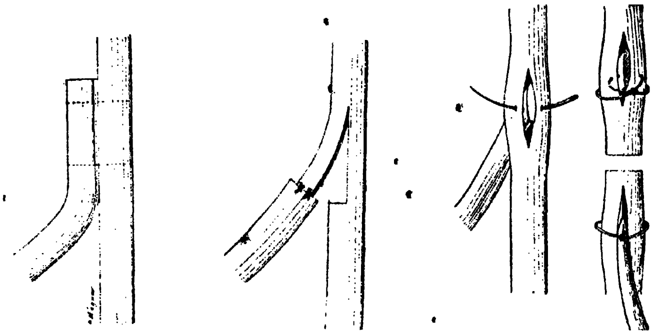


FIG. 586.—Some Methods of Tendon-Anastomosis (Ombrédanne).

for instance, if the extensor tendon has been united or an artificial tendon has been placed in the gap, the finger and wrist are placed on the splint in hyper-extension.

Experiments on union of tendon made by the author have shown that the band of uniting material will stretch with ease for six weeks immediately after the operation, and then very little further stretching will take place. It is therefore evident that this period constitutes the "critical period" of after-treatment, and that during this time complete and partial immobilisation are essential. *It is during the first six weeks after the operation* that we are able to regulate the length of the band of new material. The part is placed in such a position that no strain is thrown upon the affected tendon; and whether the position is exaggerated or not depends upon several points, the chief of which

are the width of the gap which has been bridged, the soundness of the suture effected, and the strength of the opposing muscles. Complete immobilisation is maintained for fourteen to twenty-one days. Experience shows that between the fourteenth and twenty-first day the new material is still capable of lengthening; but it has begun to harden, this condition being well marked about the twenty-first day. It is therefore mostly in the third week that we regulate the length of the uniting material. In order to do this, tentative passive movements are made, small in excursion and gentle in character. If the new material gives little or no resistance the part is further immobilised for a week. If it is strong and good, passive movements are carried out by the surgeon once a day; the range of the movements being guided by the size of the gap which originally existed in the tendon, and by the extent of the natural excursions of the tendon. The greater these are, the less the movement. At all other times the part is kept at rest. Gradually the amount of movement is increased, and by the sixth week, if the operation has been successful, the muscles governing the part are in equilibrium. Even now absolute freedom of movement is not advisable. For half the day and during the night, a splint is worn so as to keep the part under control; and we find by experience that it is not until three months have elapsed that the patient can dispense with supports.

One other point in the after-treatment is noteworthy. If any foreign material, particularly silk, is introduced between the divided tendon ends, a small catgut drain should be inserted for forty-eight hours after the operation. If this be omitted, serum collects, and the foreign material may be ultimately extruded.

Rupture of Tendon

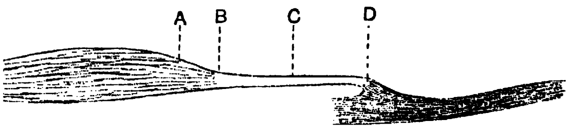


FIG. 587. Diagram to illustrate terms used. A, Site of Rupture of Muscle; B, Site of Intermusculo-tendinous rupture; C, Rupture of tendon. D, Disinsertion.

Definition.—A solution of continuity of a tendon, in the production of which muscular contraction takes part.

Rupture of tendon is more frequent than disinsertion, but rarer than muscular and intermusculo-tendinous rupture. Practically we

have to deal with it in three situations—rupture of the tendo Achillis, of the ligamentum patellæ, and of the tendon of the quadriceps. Ruptures of the tendon of the biceps brachialis, triceps, long extensor of the thumb, gluteus maximas, and tibialis anticus have been seen, but are all exceptional. In a collection of 300 cases, all

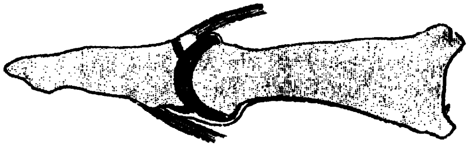


FIG. 588.—Disinsertion of Tendon—Detachment of a small Piece of Bone—Capsule Opened (Delbet).

but about ten were examples of the three first mentioned. Rupture of the tendon of the plantaris is a rarity. The so-called *coup de fouet* being generally a partial muscular rupture of the calf muscles.

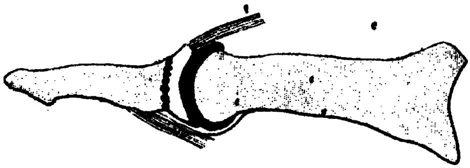


FIG. 589.—Disinsertion of Tendon—Fracture—Capsule Intact (Delbet).

Delon has collected ten cases of bilateral rupture of tendon. Certain causes predispose to this accident. It occurs generally in the second half of life and is associated with rheumatism, rheumatoid arthritis, syphilitic gummata, and possibly ataxia.

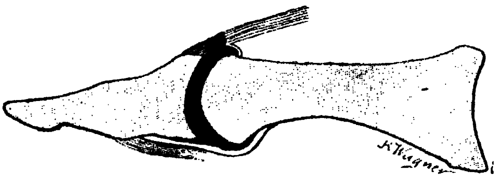


FIG. 590.—Disinsertion of Tendon—Rupture—Capsule Opened (Delbet).

Grilliat suggests, in the case of the ligamentum patellæ, that a malformation may exist either as regards abnormal length or slackness. When the quadriceps contracts, the slack is taken up and arrested with a jerk, and the rupture takes place in the manner in which a grocer's assistant ruptures a piece of string.

In the case of the tendo Achillis, J. L. Petit suggests slight

shortening due to high heels, so that the foot is incapable of sufficient dorsi-flexion, therefore a fall on to the toes may cause rupture.

Muscular contraction alone may be a sufficient cause as in swimming. Possibly, too, this is the case when the quadriceps tendon is ruptured in the attempt to avoid a fall. In other cases it is the abrupt arrest of movement, as in kicking against some object.

The patellar ligament usually gives way close to the tibia (55 per cent). Next in frequency near the patella (41 per cent); least often in the middle (4 per cent). In 70 per cent of cases the quadriceps tendon gives way close to the patella, and the tendo Achillis about $1\frac{1}{2}$ ins. above the os calcis, where it is smallest.

Treatment.—Good results may be obtained without suture by relaxation and immobilisation, but in 50 per cent of cases thus treated the result has been unsatisfactory (Maydl, Buchanan, Bull).

On the other hand, suture may always be depended on to give a perfect result. It must be borne in mind that ruptures close to the patella open the knee-joint, and an operation should not be undertaken save by the expert surgeon, and after ample precautions to ensure asepsis.

Disinsertion is seen in the extensor tendons of the fingers, (Figs. 588, 589, 590), and give rise to "Mallet-Finger" or "Dropped Phalangette," which is described in vol. i. p. 307.

LUXATION OF TENDONS

Displacement of the peroneal tendons forward from the retromalleolar groove is not infrequently met with. Other luxations of tendons are rarities. It was thought at one time that luxation of the long tendon of the biceps was common, but subsequent researches have shown it not to be so. Probably only four or five undoubted cases will bear criticism. Luxation of the anterior and posterior tibials, and the extensor of the ring and index fingers have been recorded.

Sometimes both peronei luxate, at other times the peroneus longus alone. Congenital absence of the retinaculum, malformation of the groove, some fractures and sprains predispose to this accident. The cause is a sharp contraction of the muscles, deviating the foot outwards whilst *it is in dorsi-flexion.* In paralytic talipes valgus,

calcaneus and calcaneo-valgus—a slow and progressive dislocation forward—the so-called spontaneous luxation takes place.

The symptoms are local pain, swelling, and ecchymosis, in fact, the signs of a sprain. On examination the tendons can be felt on the external surface of the malleolus. They are quite easily replaced—with the foot extended—and readily spring forward again when it is flexed.

Treatment.—In many cases it is difficult to retain the tendons in their places, but the attempt should be made. The foot should be placed at a little less than a right angle and everted,[1] the tendons pushed back in their places, a firm pad and strapping

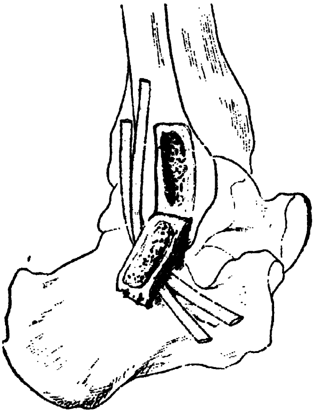


FIG. 591.—König's Operation for Displacement of the Peronei Tendons.

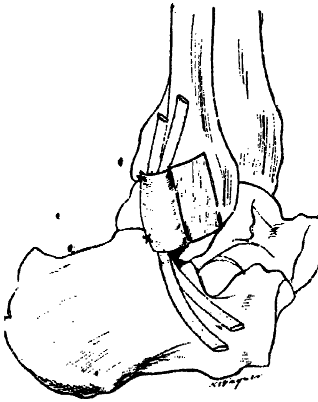


FIG. 592.—Lannelongue's Operation for Displacement of the Peronei Tendons.

applied, and the limb kept at rest in a plaster of Paris bandage. If we are dealing with recurring displacement, movements of the foot should be limited by means of a brace, with straps at the ankle-joint, to control them. The tendency to relapse, however, is so marked that operative interference is often a necessity. The tendons must be fixed in place by turning down an osteo-periosteal flap from the fibula, and suturing it to the periosteum of the os calcis

[1] In the report of a case, accompanied by a very complete bibliography, Dr. P. H. Fitzhugh points out that the lesion always occurs during a muscular effort, with the foot everted and flexed. But (he holds) this would not occur unless the gastrocnemius and peroneal muscles were shortened. If these are of normal length, the full play of the ankle-joint, even in traumatism, would not dislocate the tendon. As a corollary, stretching of these posterior muscles is an essential part of after-treatment, and by adopting this he has obtained a successful result without operation. Retentive apparatus alone was used.—*Trans. Am. Orth. Assoc.* vol. xv. 1902.

(Fig. 591), or to the tendon sheath at its posterior part (Lannelongue, Fig. 592). At the same time the bony groove is deepened. A similar line of treatment is carried out at the inner ankle for a displaced tibialis posticus tendon.

DISEASES OF TENDON SHEATHS AND TENDONS

TENO-SYNOVITIS AND TENO-CELLULITIS

We allude to the effects of inflammation in tendon and its surrounding structures, when due to infection of a wound (vol. i. pp. 771, 785). We now deal with the so-called primary inflammatory affections of these parts.

It is generally conceded that a pure uncomplicated tendonitis does not occur, or that inflammation of a tendon, apart from that of its synovial sheath, or of its cellular covering is not met with. It is true that certain authors [1] have recently described a tendonitis in the case of the Achillis. Thus, Schanz suggests the name "Tendonitis Achillea traumatica;" Von Baracz, "Tendonitis Achillea arthritica." But we cannot see in what way the cases differ from the "cellulite péritendineuse" [2] of the tendo Achillis, as first described by Folet, and subsequently by Raynal, Kirmisson, De Boris, and others.

Teno-cellulitis is met with chiefly in the Achillis, and gives rise to one of the varieties of Achillodynia (an affection first described fully by Albert, and due in most cases to bursitis, see vol. i. pp. 806-808). According to the French military surgeons it is also seen in the space above the ankle, on the front of the leg where the extensor tendons pass down in a compartment formed internally by the tibia and externally by a prolongation of the fascia lata. It has also been described as taking place at the radial insertion of the biceps, and on the dorsum of the foot about the extensor tendons.

Symptoms.—In the case of the tendo Achillis a painful swelling of a cylindrical or spindle shape appears. It is situated well

[1] Schanz, "Eine typische Erkrankung der Achillessehne," *Zentralbl. f. Chir.*, 1905, 48; Drehmann, "Eine typische Erkrankung der Achillessehne," *Zentralbl. f. Chir.*, 1906, 1; V. Baracz, "Tendonitis achillea arthritica als eine besondere Form der Achillessehnenerkrankung," *Zentralbl. f. Chir.*, 1906, 1.

[2] Raynal, "Cellulite péritendineuse du tendon d'Achille," *Arch. gén. de méd.*, 1883, p. 677; Kirmisson, "Contribution à l'étude des affections du tendon d'Achille," *Arch. gén. de méd.*, 1884, p. 100; De Boris, "Péritenosites," *Un. méd. du nord-est*, 1899, p. 113.

above the os calcis and is therefore unconnected with any bursa. In some cases it has been described as being localised where the margin of the "upper" of the shoe infringes, suggesting a traumatic origin. But usually the overlying skin is neither reddened nor œdematous, and the swelling may be higher up; or, as described by Kirmisson, several separate nodes, even four or five may be present at intervals along the tendon. The part is stiff and, if movement is attempted, painful. Sometimes friction sensations are perceptible. The affection comes on insidiously, over-use and strain seem to predispose to it, and rheumatism, gout, gonorrhœa, and influenza are thought to be determining factors. It runs a benign course, terminating, as a rule, after a few weeks, in resolution. Nevertheless, in some cases more or less permanent thickening and hardness, indicative of a sclerotic change, persist. Indeed it is likely that some examples of fibromata of the tendo Achillis originate in this affection.

The tendons on the front of the leg may be affected after a prolonged march. Stiffness, disability and pain come on, accompanied by a deep swelling on the front of the limb, beginning one inch above the instep and extending upward for two or more inches; the skin may be œdematous. Sensations of pseudo-fluctuation and pseudo-crepitus may be elicited, but in neither of the above cases does the affection ever run on to suppuration.

Treatment consists of complete rest, keeping the affected muscles relaxed by strapping appropriately placed, and of pressure by cotton wool and a bandage. Painting with iodine is useful in the acute stage, and later massage and dry heat baths. Any general disorder must be appropriately treated.

Teno-Synovitis

As the serous membranes are closed sacs, with the visceral layer in contact with and gliding against the parietal layer, so the tendon synovial sheaths are closed canals with a peritendinous or visceral layer and a parietal layer, lining the osseo-fibrous canal in which the tendon glides. Whilst the serous membranes have a definite endothelial lining, the very thin wall of the synovial sheaths consists only of imperfectly differentiated areolar tissue, the cells taking on here and there an endothelial arrangement. The cavity contains a small amount of a glairy synovial fluid.

The largest synovial sheaths are the following: those of the

flexor tendons in the hand. The index, middle and ring fingers have separate sheaths, which terminate near the roots of the fingers. The tendons of the thumb and little finger have sheaths which are prolonged up beneath the anterior annular ligament and assist the flexor tendons in gliding under this structure. At the back of the wrist are the sheaths lining the six osseo-fibrous compartments formed by the posterior annular ligament and the radius and ulna. In the foot there are the sheaths, under the anterior annular ligament, of the extensor proprius pollicis, the tibialis anticus, and the extensor longus digitorum. Behind the inner ankle are the sheaths of the tibialis posticus and flexores longus digitorum and pollicis, and behind the outer ankle that of the peronei.

In teno-synovitis the wall of the sheath becomes changed and the contents modified in various ways, giving rise to different types of the affection. The chief of those are:

I. The Dry Type.
II. The Serous Type.
III. The Suppurative Type.
IV. Proliferating Type.
V. The Tuberculous Type.

I. Dry or Crepitant Teno-Synovitis

The situation in which this is most frequently seen, or rather felt, is above the wrist on the radial aspect of the fore-arm, at the spot where the tendons of the abductor longus pollicis and extensor brevis pollicis cross the tendons of the radial extensors of the carpus. It is stated by some anatomists that a bursa separates the extensor tendons of the thumb from those of the radial extensors, especially in the case of those whose occupation entails much rotation of the hand, as in the use of a screw-driver. It is possible therefore that some of these cases are really bursitis and not truly synovitis—a distinction in this particular case, almost unnecessarily fine. This affection is met with in the sheaths of the peronei, the long tendon of the biceps, the extensor communis digitorum at the back of the wrist, and in the extensor sheaths of the thumb at the level of the wrist.

It is seen chiefly in adult males, whose occupation is laborious, and it is especially frequent in those who have arthritic trouble, particularly in those who are liable to rheumatic affections. The

onset is usually sudden. The signs are pain and tenderness in the tendon sheath, and perhaps a slight swelling. If the patient is made to move the part, a fine friction or crepitation will be felt. This is variously described as being like the rubbing of silk, or the creaking of new leather. The prognosis is good. Rest, support for a few days, and firm pressure, are indicated. Relapse is not uncommon.

II. Serous Teno-Synovitis

Ombrédanne states that this is usually a manifestation of some subacute pyogenic infection. Thus, it is met with in gonorrhœa at any stage, in acute rheumatism, in secondary syphilis, and in scarlet fever. It is usually found in the same places as the "dry" form—of which it is simply a more advanced stage. The sheath is distended with serous effusion, and a characteristic elongated tumour forms. Where the tendon passes under a constricting band, such as the annular ligament, the tumour is compressed and is lobulated in shape. There is, as a rule, not much pain except on movement, and it may then be very acute. Complete rest on appropriate splints, pressure and bandaging usually give speedy relief. If a chronic condition supervenes, anxiety as to whether the underlying cause may be tubercle, or whether a transformation into a tuberculous teno-synovitis is taking place, may be felt.

III. Suppurative Teno-Synovitis

may originate in

A. Direct infection, for example, a punctured wound of the finger, introducing septic material into the sheath. This is very serious in the little finger or thumb, owing to the prolongation of the sheath above the annular ligament.

B. More often it is due to the spread of disease from some neighbouring structure. Thus an osteomyelitic focus, or a cellulitis, may eventually invade the synovial sheath.

C. Rarely the infection is through the blood stream. The most frequent examples of this class are seen in pyæmia. It occurs also in scarlet fever, typhoid fever, pneumonia (Vidal and Mercier have seen a pneumococcic synovitis), or it may be due to the gonococcus (Tollemer and Mascaigne).

The tendon sheath becomes distended with pus, in a part or in

the whole of its extent, its wall becoming converted into an abscess sac. The tendon softens, becomes infiltrated, and eventually sloughs. The surrounding tissues are œdematous and indurated. The pus perforates the sheath, burrows into the connective tissue, and the skin may give way.

The constitutional symptoms are correspondingly grave.

Treatment.—Early and free incision of the tendon sheath is required. In some cases it is possible to open both ends of the sheath, pass a drain along, and irrigate with sterile salt solution. It must be borne in mind that it is not always easy to distinguish a cellulitis from a teno-synovitis—for example in the fingers—and in laying open a cellulitis, if we cut too deeply, the underlying sheath may be opened and infected, whereas otherwise it might have escaped. Von Bier's method is thought by some to be of use, but others have not found it superior to continuous, hot baths. In using the latter it is probable that strong antiseptic solutions do more harm than good, as they do not reach the part affected, whilst they diminish the vitality of the parts they touch. Their object is to promote a free flow of blood to the part, with relaxation of the tense structures. Every effort is to be made to preserve the part, and amputation is a final measure.

Results of Teno-Synovitis

A. Plastic Changes.—In a suppurative case, after the formation of pus ceases, the internal wall of the sheath is no longer smooth and shiny, but is converted into ordinary granulation tissue, and adheres closely to the tendon. The whole tendon and sheath eventually form a more or less indurated and contracted fibrous cord. In such cases treatment avails little, but we must not be too ready to assume that no improvement will take place. In cases seen a year afterwards, the parts often show a marked improvement. In less marked degrees, that is, in subacute infection, or in gonorrhœal cases, the adhesions are less numerous and diffuse; prolonged massage, dry heat, and passive movement are of use.

B. Hyperplastic Changes.—Stenosing fibrous teno-synovitis, *e.g.* one form of snapping or jerk finger. In this affection the generally accepted explanation is that there is an inflammatory or post-traumatic thickening, with subsequent stenosis of the tendon sheath—the stenosis setting up grooving and irregularity of the tendon itself.

IV. Proliferating Teno-Synovitis

In this affection, described by König and Kümmer, papillomatous and pedunculated excrescences, due to chronic teno-synovitis, arise on the internal surface of the sheath. The interest of the condition lies in the possibility that the pedicles may give way and thus originate the fibrous foreign bodies described by Vilhemin.

Arborescent Lipoma of the Tendon Sheaths.—Ten observations are recorded by Billroth, Haumann Kurz, Haeckel, Lendler, Garre, and Kümmer,[1] in the following situations: affecting the sheaths of the extensor tendons of the fingers six times, the flexors of the finger twice, the peroneus brevis once, and the extensor carpi radialis longior once.

The affection is not tuberculous, but is a fibro-lipomatous degeneration of the tendon and its sheath, inflammatory in origin (Kümmer) and allied to the "proliferating synovitis" of Kümmer. There is a soft, elastic, pseudo-fluctuating swelling, with false crepitus present. As a rule it is painless. Before operation, it is practically impossible to diagnose it by its local characteristics from tuberculosis, unless the von Pirquet reaction is employed.

The form of treatment which has been used is excision, when the swelling has caused serious inconvenience and partial loss of use in the part.

Foreign Bodies in Tendon Sheaths.[2]—There are only eight observations recorded, and the extraneous material was found to be either a fragment of a fractured bony process or an osteophyte.

Teno-Synovial Cysts have been described by Foucher, Demarquay, Larger, and Franz.[3] They are much rarer than arthro-synovial cysts, and those observed by Erichsen, Lyot, and Müller were at the level of the first phalanx of the middle finger. I have seen them three times, at the base of the first phalanx of the thumb on the palmar aspect. They give rise to a prominence of the sheath, and closely resemble, if they are not identical with, simple tendon ganglia.

Franz explains their origin as arising from local hyperæmia due to repeated mechanical irritation, which sets up cell-proliferation and hyperplasia. The cells undergo colloid degeneration in the centre.

[1] Cf. Kümmer, *Rev. méd. de la Suisse romande*, 1894, p. 287.

[2] Riou, Thèse de Paris, 1897-98.

[3] Cf. Franz, "Kystes synovieuses de la face palmaire de la main," *Archiv f. klin. Chir.*, 1903, Bd. lxx. p. 973.

and a cyst forms. Franz, Payr, Ledderhose, and Thorn deny that they are primarily connected with the sheath at all. They say they are false bursæ developed over the sheaths. The treatment is extirpation.

Cysts have also been known to develop in the tendon-substance, and have been described by Auvray, Morestin, Borchardt, Morian, Essen, and Hoffmann. They are pathological curiosities, and when situated in the flexor tendons of the fingers, as they pass through the osseo-fibrous grooves, they have given rise to jerk finger.

Ganglion of the Tendon Sheath

English surgeons use two terms, simple and compound ganglion. The latter is an unfortunate expression, because it fails to indicate either the nature or the gravity of the affection. A compound ganglion is a tuberculous teno-synovitis affecting the great palmar sheaths of the hand. It is described on pp. 790-793, under its appropriate heading.

A "simple" ganglion is a cyst developed in the synovial membrane (Ombrédanne), and is filled with clear colloid material. They are situated, generally, on the dorsal surface of the wrist, and may there be connected with one of the extensor tendons, or they are seen on the dorsum of the foot in the neighbourhood of one of the tarsal joints. Occasionally, they appear on the outer side of the knee-joint in front of the biceps tendon, and they are also met with in other situations, which, on account of the rarity, it is not necessary to specify.

Pathology.—Much discussion has arisen on this point, and various theories have been advanced. We may say, however, that the view generally accepted is that a simple ganglion is a degeneration cyst arising in the tendon sheaths and the capsule of joints. It has been freely stated and widely accepted that they are herniæ of the tendon sheaths or joint capsule, but the difficulty is that no communication has been shown to exist between the cavity of the cyst and that of the tendon sheath or joint-cavity. A feasible explanation of the origin of ganglia is that a small portion of the synovial membrane has become protruded and cut off, and it may then have degenerated into colloid material. Ledderhose and others (see Teno-Synovial Cysts) regard them as colloid degenerations of the fibrous tissue of the capsular ligament, which occur at first in numerous small areas, and later run together and form a

simple cavity. Sometimes, however, they may arise from a lymphangiomatous condition either of the tendon sheath or of the tendon itself.

When the cyst is dissected and examined, it is found to have a dense fibrous capsule, closely adherent to the adjacent tissues, and not lined with endothelium, the viscid contents being in immediate contact with the fibrous wall.

Clinically, a simple ganglion on the wrist (carpal ganglion or sprained sinew of the wrist) is a rounded or oval swelling situated on the dorsal surface, towards the radial side. It varies in size from a pea to a walnut, and the skin and fascia are not adherent to it. It does not move with the tendons, but becomes more prominent and tense on flexion of the wrist. Its appearance is gradual and follows some strain of the wrist, especially in girls, and is often seen in those who practise the piano assiduously, and in washerwomen. Beyond a feeling of weakness, a ganglion often gives rise to no symptoms; but some patients, especially girls, complain of partial loss of power in grasping objects or lifting heavy weights, and of pain which shoots up the arm.

Ganglia on the dorsum of the foot are smaller, flatter, and more tense than those on the wrist, and on account of their hardness are sometimes mistaken for a bony growth. They rarely give rise to symptoms, except such as arise from pressure by the boot. When situated about the knee, they are generally found in athletic young males, and may cause stiffness and some difficulty in moving the joint.

Treatment.—Occasionally, frequent application of Lin. Iodi or a blister or two, succeeded by firm pressure when the skin has healed, and keeping the joint immobile in a splint, will be followed by disappearance of the swelling. We do not recommend "dispersing" the ganglion by a smart blow. It is seldom permanently successful, and is painful. A method of treatment which we are in favour of is the injection of five minims of carbolic acid into the sac. A small incision is made into it with a tenotomy knife, the contents evacuated, the carbolic acid inserted with a subcutaneous syringe, and the part dressed and splinted. Some irritation follows, and the ganglion seldom recurs. Thomson and Miles [1] recommend transfixion of the skin and ganglion by a double thread of silkworm gut, done antiseptically, and the parts are then dressed. In a week the threads are removed, and the wound sealed

[1] *Manual of Surgery*, 3rd ed. vol. i. p. 225.

with collodion.[1] If these methods fail, the ganglion should be excised.

Rheumatic Tendonitis and Teno-Synovitis.—In rheumatic subjects, hard, more or less rounded nodules appear either during an attack of the fever or apparently independently of it. They are subcutaneous and may be attached to the sheath of the tendons, or directly to the latter structures. They are about the size of a pea, multiple in number, and most frequent about the fingers, hands, and wrist; less so about the elbow, knees, scapulæ, and spine.

They occur more often in children than adults, last for weeks and months, and finally disappear.

Gouty Teno-Synovitis.—Either the sheaths or the tendons themselves may become the sites of deposit of masses of urate of soda, which lie beneath the endothelium, and vary in size from a pea to a cherry. They may merely cause deformity, but occasionally, by their bulk and attrition, limit movement. If large, the deposits should be excised.

Tendonitis.—Sometimes the tendon substance becomes inflamed, either from the spread of septic infection to it, or in gouty and rheumatic people, who have over-strained the tendon, especially the tendo Achillis. It gives rise to one form of achillodynia. The tendon is swollen and painful throughout its length, and is very tender on movement. Occasionally gouty nodules form in the tendon substance. Constitutional remedies, assisted by rest, dry heat, and temporary fixation, soon give relief in the gouty and rheumatic forms.

V. Tuberculous Teno-Synovitis

Tuberculous teno-synovitis is met with in two forms: (1) That in which rice-shaped or melon-seed shaped bodies are present; and (2) the fungating variety. Sometimes a serous form is described. It is certainly rare, and is possibly due to tuberculous infection of a chronic serous teno-synovitis; still, it may be, in some cases, as Schuchardt and Tédenat opine, tuberculous from the start. There are no hard-and-fast lines of demarcation between the various forms, intermediate stages are met with, and the transformation from one to the other may be observed. The differences depend on the virulence of the infecting agent, and the degree of immunity of the subject. The "fungating" is the most severe form. It may be

[1] We have recently read that ganglion of the wrist has been successfully treated by injecting thiosinamin (*Guy's Hospital Gazette*, March 1910).

merely the end-stage of a less serious variety, or it may be "fungating" from the start. In surgical and other forms of tuberculosis, save in certain rare cases, the bacilli are distributed by the blood-stream, and the terms "primary" and "secondary" can only be used in a general way. By "primary" we mean that no antecedent or older tuberculosis other than the one under observation can be demonstrated. This question we have dealt with elsewhere (Vol. II. sec. i.). In the fungating form of teno-synovitis the patient is often found to be phthisical, and the local lesion is probably secondary to the pulmonary disease. In the rice-grain variety it is not always so, and the local lesion may be cured before any other tuberculous lesions have appeared. The milder form, however, may become fungating, and phthisis pulmonalis or other visceral infection occur.

Either form may arise by direct extension and infection from an arthritic or osseous focus. This is frequently the case in the fungating form, especially in the tarsal region.

(1) Tuberculous Teno-Synovitis associated with Rice-Shaped Bodies

This form, similarly to the fungating type, usually attacks young adults of both sexes, between the ages of eighteen and twenty-five years. The subjects often appear to be otherwise in good health. The usual sites are at the back of the hand in the extensor sheaths, behind the malleoli in the peroneal or flexor sheaths, and most frequently on the front of the wrist and in the palm (Compound Ganglion).

Symptoms.—Feelings of weight and fatigue are first noticed. Then an elongated swelling appears in the course of the affected sheath. It is of a doughy, semi-fluctuating consistence, and where bound down by resistant structures, such as the annular ligament, is bi-lobed. The characteristic sign is elicited by pressure with the finger on the swelling. The rice-grain or melon-seed shaped bodies slip from under the finger with a little jerk or crepitation. This sign is especially well marked if the distended sheath is constricted at one part. Thus, when the great flexor sheath of the palm is affected, if the observer places the fingers of one hand on the swelling in the palm, and the fingers of the other on the swelling above the wrist, the bodies will be felt to slip through the narrowing caused by the annular ligament. It is stated by

Chassaignac that a narrowing of the sheath is essential to the production of this sensation, and Michon has demonstrated this point in the following manner. He filled a bladder partially with water and grains of rice, and found palpation caused no characteristic sensation. He then placed a ligature around the centre of the bladder, thus forming a narrow isthmus. Alternate pressure then gave rise to the sensation.

The disease at first runs a very chronic course, the patient being free from fever and toxic signs. Spontaneous resolution may occur, or cure may result from appropriate treatment. On the other hand, cold abscess may form, which involves the skin and perforates it, and the lesion assumes a fungating character owing to septic infection. There is great risk of extension of tuberculous disease to the bones, and disorganisation of the wrist-joint.

Pathology.—The pathology of this condition has given rise to much discussion, and even now in certain minor points uncertainty exists. Rice-shaped bodies have been known since the early part of the nineteenth century, but it was not until 1876 that their tuberculous nature was suspected by Hoeftmann. Baumgarten in 1884, and Nicaise, Poulet, and Vaillard in 1885, histologically and by inoculation demonstrated the tuberculous nature of the lesion. The production of the actual bodies is largely mechanical, but rice-grain teno-synovitis apart from tubercle has not been demonstrated.

On cutting into the sheath, a variable number, often very large, even it may be hundreds, of rice-like bodies escape. They are smooth, white, opalescent, polished, and sometimes faceted. They vary in size and may be as large as a small bean, a quarter of an inch being about the average length. Their shape is more that of a melon-seed than a rice-grain, being discoidal, thin at the edges, thick in the centre, and about twice as long as they are broad. They are composed of a fibrinoid substance, and histologically may be described as either stratified or reticulated in structure. Remains of leucocytes, epithelioid cells, and possibly even typical tubercles, may be seen. In certain sections, examined by Ombrédanne and Lettule, the identity of their structure with that of the innermost layer of the wall of the sheath was fully recognisable. And in some instances the rice-shaped body was still attached by a fibrous or fibrinoid pedicle to a point on the sheath wall where the degeneration was less marked.

The sheath or wall is thickened and is composed of inflammatory and young fibrous tissue, interspersed with tubercles, which in

some places consist of a single giant-cell surrounded by a zone of epithelioid cellules, and at others, especially in the outer layers, of confluent tubercles. The inner layer of the wall shows a necrotic condition both of the tubercles present of the cells, and connective tissue and vascular walls; and the innermost layer of all is thin,

FIG. 593.—Microscopical Section of a Tendon Sheath affected with Tuberculosis. R, Rice-grain Bodies adherent to the Sheath-Wall; H, Hyaline Degeneration of Tissues; T, Inflammatory Tissue infiltrated with Lymphoid Elements; F, Tuberculous Follicle; S, Fibrous Tissue (Ombrédanne after Letulle).

glassy, homogeneous; here the process of coagulation-necrosis is most completely marked.

Origin of the Rice-Shaped Bodies.—It was formerly thought that these were coagulative in character and due to production of

true fibrin either from intracystic hæmorrhage, or apart from hæmorrhage, from the effused serum. But it is now known that their structure, although fibrinoid, is not true fibrin. There is no doubt that they have their origin in the irregular disintegration of the innermost necrosing layer. Here and there little peninsulas are left jutting out, composed of elements in which the necrotic change is not quite so fully advanced. These become pedunculated, break off, and are rounded and polished by the movements of the tendon. This view appears more likely than the idea hitherto accepted that they are formed by lamellæ of the amorphous innermost layer, which became rolled or folded up, engulfing some of the cellular and less disintegrated elements.

Ombrédanne (*Nouveau traité de chirurgie*, vol. ix.) gives many references, the most important of which are:—

LUCKE. Deutsche Zeitschr. f. Chir., 1872, p. 466.

LAFOSSE. Synovites à grains riziformes du poignet et de la main. Thèse de Paris, 1882.

WEISS. Rev. de chir., 1885.

NICAISE, POULET, VAILLARD. Nature tuberculeuse des hygromas et des synovites à grains riziformes de la cuisse. Rev. de chir., 1885.

REVERDIN ET MAYOR. Abcès ossifluent à grains riziformes. Rev. de la Suisse romande, 1887.

WALLICH. Nature tuberculeuse des synovites à grains riziformes. Soc. de biol., 17th Nov. 1888.

DABAN. Nature de la synovite à grains riziformes. Thèse de Paris, 1889.

GARRÉ. Beitr. zur klin. Chir., Bd. vii.

MULLEZ. Extirpation des synovites à grains riziformes. Thèse de Paris, 1893.

SCHUCHARDT. Archiv f. pathol. Anat., 1894, Bd. cxiv.

RIESE. Deutsche Zeitschr. f. Chir., 1895, p. 1.

VOLKOVITCH. Presse méd., 1897, No. 22, p. 122.

GANTOIS. Thèse de Paris, 1900-1901.

GIGNOZZI. Riforma med., 1906, p. 366, with Bibliography.

In making the diagnosis, certain other but rarer conditions should be borne in mind. In arborescent lipoma of the tendon sheath, the pedunculated fibro-lipomatous fringes may give rise to the sensation of bodies slipping away with a jerk. Syphilitic teno-synovitis and malignant disease—in which the glands are generally enlarged—are to be thought of; and lastly, a simple chronic teno-synovitis, the existence of which is, however, doubtful.

(2) Fungating Teno-Synovitis

Pathology.—The chief researches establishing the nature of the affection are those of Trélat, Latteux, Lannelongue,[1] Terrier and Verrchère.[2]

The fluid contents are, as a rule, scanty, and they may be serous in character, yellow or green in colour, and sometimes hold in suspension yellow or grey grumous, or occasionally red masses, the last named being due to altered blood. The tendon generally looks healthy, but is at times dull and eroded, and its surface may be invaded by granulations. The wall is composed of three layers: (1) Internally we see the granulations, which are sometimes covered by endothelium, as if the tuberculoma were extra-synovial. But in most instances the disease is clearly intra-synovial. The fungosities are exuberant, mulberry-like, sessile, and more or less translucent. Sometimes they are pale and semi-transparent like the tissue of an oyster, and at other times they are pink, red, or maroon where hæmorrhage has taken place. Very rarely are the granulations small and villous. (2) Beneath the fungoid-like internal layers is a network of vessels. (3) Externally is the lardaceous layer, which is striated, white, and hard, often ½ to 1 cm. thick. It is very resistant to curetting; and whilst doing so we may see here and there a little mass of granulations about the size of a pea, which indicate the orifice of a diverticulum and lead into another pocket, or if towards the skin, a fistula. The surrounding tissues are chronically œdematous, and the muscular interspaces are gelatinous. Sometimes the diverticula lead to bone or joint, especially on the tarsus, and less frequently at the wrist. Histologically, the lesion is characterised by the development of enormous numbers of typical tubercles, giant cells are in abundance, surrounded by epithelioid cells, but there are few bacilli demonstrable.

Symptoms.—The onset is insidious. A swelling appears, elongated, and occupying the position of a tendon sheath, which is at first elastic and non-fluctuating, and the characteristic crepitation of the rice-grain form is absent. Fluctuation is not present in the early stages, and so long as the tumour is not adherent to the sur-

[1] Lannelongue, *Bull. de la Soc. de chir.*, 1878, p. 295; Terrier et Verrchère, "De la synovite tendineuse tuberculeuse et en particulier de la synovite tuberculeuse des gaines, du poignet, de la main et des doigts," *Rev. de chir.*, 1882, p. 543.

[2] Chandeleux, "Des synovites fongeuses articulaires et tendineuses," Thèse d'Agrégation, 1883.

rounding tissues, it may move somewhat with the tendon, and is capable of being displaced sideways, but not up and down. Later, it may become semi- or completely fluctuating, and is often lobulated. Pain at first is not severe, but it becomes so later. If tender points are a marked feature, they are indicative of osseous implication. Later, the signs are those of a cold abscess, until the skin is almost perforated. The glands are unaffected, until secondary infection is set up. The skin finally gives way and fistulæ result, so that the patient suffers from chronic septic absorption. Lung symptoms may appear, or, if already present, are aggravated, and the patient usually succumbs to general tuberculosis. As to the local disability, the part is at first held in that position in which the tendons are relaxed; later, the part becomes fixed in this position owing to the destruction of the tendon and matting of tissues. Spontaneous cure sometimes happens. It is also remarkable how long some cases go on before fistulæ form, occasionally for ten to fifteen years.

Treatment.—Zöppritz[1] holds the view that as these cases are tuberculous the only rational treatment is complete extirpation. He records 35 cases thus treated, and of 31 subsequently examined 25 had remained perfectly well, and in more than half the function of the hand was completely restored. On the other hand, it must be stated that other surgeons have by no means seen such brilliant results. Further, if the patient is markedly phthisical, any such necessarily severe and prolonged operation is out of the question—for, unless the removal is thorough and complete, it is best left alone, or it should be treated in a less heroic manner. In children radical operation is rarely called for, as they often show considerable resistance to localised or surgical tuberculosis. When, however, an operation has been decided upon, the tumour is laid freely open, and carefully curetted, the tendons being preserved from injury. All pockets must be followed up and treated like the main cavity, and any osseous focus freely cleared out. The wall of the cavity is then dissected out as completely as possible, and in order to do this such structures as the annular ligament may require division, care being taken of the median nerve. In some places, for example the front of the wrist, complete extirpation of the sheath is difficult, but must be done as a last resource. Jacobson[2] narrates four successful cases. The operation should be as thorough as circumstances permit, and all diseased tissue cleared away with the curette.

[1] *Beitr. z. klin. Chir.* Bd. xxix. Heft 3.

[2] Jacobson and Rowlands, *Operations of Surgery*, 5th ed., vol. i. p. 39.

If less radical treatment is decided upon, various measures are at our disposal. Rest, splints, and compression with cotton-wool are useful. Various injections have been employed such as glycerine (Mickulicz), iodoform in ether (Kirmisson), naphthol and camphor, sulphate of zinc (Le Fort), Lannelongue's "intra-articular" solution—*i.e.* olive oil, 40 parts; ether, 40; iodoform, 10; creosote, 2. The last has been found satisfactory by Ombrédanne, and he considers that such measures—especially in serous cases where the diagnosis is not quite certain—may be of value. Further, a few drops of Lannelongue's chloride of zinc solution may be injected here and there around the sheath in order to set up sclerosis. Von Bier's method is worthy of trial, and of course the open air and dietetic treatment for tuberculosis must be rigorously carried out, and possibly the use of tuberculin, either with or without the guide afforded by the opsonic index, as dealt with elsewhere in Vol. II. sec. i.

Gonorrhœal Teno-Synovitis affects the tendon sheaths about the ankle and wrist. Two forms are met with, the mild and the phlegmonous. In the former, pain, loss of movement, œdema, and a fluctuating swelling develop. In the latter, there are all the signs of phlegmonous inflammation, and pus may form in the tendon sheath. But the tendon usually escapes. Rest, Bier's treatment, and the use of either vaccine or serum, or both, effect a cure. In the phlegmonous form it may be necessary to lay open the tendon sheath. The affection is very liable to relapse, and alternates with inflammation of one of the larger joints.

Syphilitic Affections of Tendons and Tendon Sheaths

In the tertiary stage of syphilis the tendons may be the seat of either a gummatous infiltration [1] or of a definite tumour. And the gumma may be seated either on the surface of the tendon or develop within it. It is chiefly the largest tendons or stoutest aponeuroses which are attacked, for example the tendo Achillis, the tendons of the biceps and triceps, the aponeurosis of the vasti—and of these the tendo Achillis takes the first place in importance and frequency. The flexor tendons of the fingers are also sometimes affected.[2] There is usually not much difficulty in the diagnosis.

[1] Schirren, *Deutsche Zeitschr. f. Chir.* Bd. lxvii. p. 132. This form may be painful; generally, syphilitic infections are indolent and painless. Sabail, Thèse de Paris, 1876.

[2] Bouisson, *Gaz. méd. de Paris*, 1846; Notta, *Archives gén. de méd.*, F. xxiv. p. 142.

The history of the patient, the traces of secondary lesions or the presence of other tertiary signs, and the character and situation of the tumour or thickening are sufficient. In certain cases the firmness and solidity of the swelling may at first lead one to suspect a fibroma. The effect of the lesion is variable. If seated on the surface of a tendon, it is not likely to interrupt its continuity, as more or less cicatricial adhesion results. On the other hand, a gumma of considerable size in a tendon may weaken it so that it gives way (Poirier). Under appropriate treatment a gumma may be resolved;[1] or, especially in the diffuse form, more or less sclerotic changes may follow, or even patches of calcification.

Syphilitic Teno-Synovitis

is rarely met with. In the *secondary* stage the sheaths of the extensor tendons of the hands and feet sometimes suffer. The onset

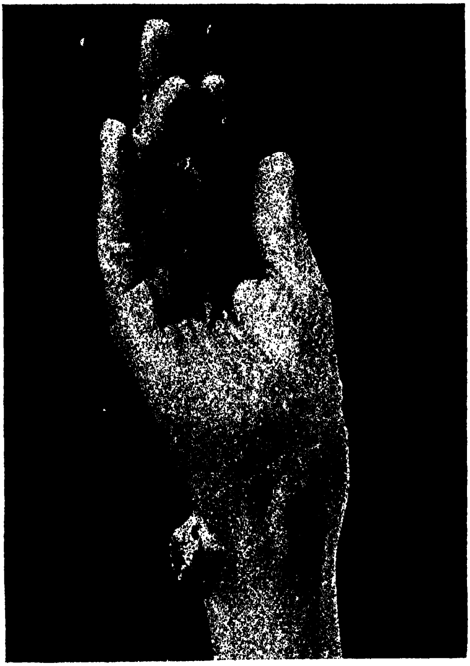


Fig. 594.—Late Syphilis affecting the Sheaths of the Flexor Tendons of the Thumb and Fingers, with a Pustular Syphilide on the inner border of the Fore-arm (Ombrédanne).

[1] Lisfranc, *Gaz. des hôpitaux*, 1842. The case of an opera dancer with a large tumour in tendo Achillis, cured by iodide of potassium (quoted by Lancereaux).

may be sudden, but is more often insidious. Pathologically, the form may be either dry or accompanied by serous effusion. The main characters are that it is bilateral and symmetrical; it is painless, free from tenderness, chronic, and gives rise to but a small amount of disability.

In the *tertiary* stage a tendon sheath may be attacked by gummatous infiltration. This has been seen on the sheaths of the flexor tendons of the fingers, where it may be mistaken for whitlow, and on those of the extensor tendons of the toes. It has also been met with in the peroneal sheath, and in that of the biceps brachialis and femoris. The age and history of the patient, and if breaking down has taken place, the characters of the ulcer, slough, and discharge all aid in the diagnosis. But the differentiation from tubercle or sarcoma may at times be almost impossible.

MAURIAC. Synovites tendineuses symptomatiques de la blennorragie et de la syphilis. Leç. sur les malad. vénér., 1890, p. 470.

SCHUCHARDT. Tuberculose et syphilis des synoviales tendineuses. Arch. f. path. Anat., 1894, p. 186.

LE DENTU. Clinique chirurgicale, Paris, 1904, p. 245.

Earlier references which may be of value are:—

VERNEUIL. Hydropsie des gaines tendineuses des extenseurs des doigts (Gaz. hebd., 1868, p. 609, and 1873, p. 22).

FOURNIER. Note sur les lésions des gaines tendineuses dans la syphilis secondaire (Gaz. hebd., 1868, p. 645).

CHOUET. De la syphilis dans les bourses séreuses articulaires, sous-cutanées et tendineuses. Thèse de Paris, 1874.

ROCH. Hydropsie des gaines tendineuses dans la syphilis secondaire. Thèse de Paris, 1874.

NOTTA. Recherche sur une affection particulière des gaines tendineuses de la main, caractérisée par le développement d'une nodosité sur le tendon des fléchisseurs des doigts. Arch. gén. de méd. F. xxiv. p. 142.

VAN OORDT. Gommes des tendons. Thèse de Paris, 1859.

CHASSAIGNAC. De la dactylite syphilitique. Clinique européenne, July 23, 1859.

NÉLATON. Du panaris syphilitique. Gaz. des hôpitaux, Feb. 1860.

NEW GROWTHS OF TENDON AND TENDON SHEATHS

It is very rare to meet with innocent tumours such as lipoma, fibroma, and myxoma, and clinically they closely resemble tuberculous disease. All varieties of sarcoma occur, but they present no very distinctive features. Thomson and Miles call attention to myeloma, "which is met with at the wrist or ankle as an elongated swelling of slow development, or over the phalanx of a finger as

a small rounded swelling. The tumour tissue when exposed by dissection is of a chocolate or chamois yellow colour, and consists almost entirely of giant cells. The treatment consists of dissecting the tumour tissue off the tendons, and this is usually successful in

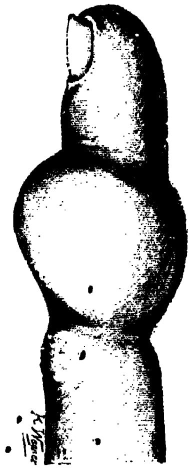


FIG. 595. New Growth, probably Sarcomatous, affecting the Sheath of the Flexor Tendons (Bonjour).

bringing about a permanent cure." Ombrédanne, writing in Le Dentu and Delbet's *Nouveau Traite de chirurgie*, p. 171, gives a considerable bibliography, and Malherbe ("Myélome des gaines tendineuses," *Congr. de chir.*, 1896, p. 907), has collected the literature to that date.

CHAPTER III

INJURIES AND DISEASES OF BURSÆ

Bursitis, Traumatic, Hæmorrhagic, Acute, Subacute, Suppurative, Serous—Hygroma—Tuberculous and Syphilitic Bursitis—New Growths, Achillodynia.

BURSÆ do not all conform to one structural type, but present every gradation from a simple enlarged areolar space with no serous or endothelial lining at all, to a definite synovial sac, with a more or less complete endothelial lining, and containing a small amount of synovial fluid. As a rule deeper bursæ, in the neighbourhood of the joints, with the cavities of which they often communicate, are the most completely developed structurally, whilst the superficial and subcutaneous are least so. The bulk of the latter are acquired, and their development depends largely on the occupation and habits of the subject. Some bursæ are frankly adventitious, such as those which develop over a spinal prominence in Pott's disease, over the cuboid in talipes varus, the bunion in hallux valgus, and over an exostosis (exostosis bursata). Purely adventitious bursæ are sometimes called "false." Bursæ, whether normally situated or adventitious, superficial or deep, when unduly distended, form bursal cysts or hygromata. But many of the deep bursæ, especially near the knee-joint, are really diverticula of the synovial membrane of the joint, and might when enlarged be more correctly described as ganglion. Such cysts take part in the pathological processes to which the joint is subject, and they do not show the same tendency to fibroid changes and solidification of their contents as the subcutaneous hygromata do.

Of the professional or occupation hygromata some are caused by the enlargement of a bursa normally present, an instance being miner's elbow; in others the bursa is a new formation, for example, the subcutaneous hygroma on the inner side of the rider's knee. In still other cases, *e.g.* tailor's bursa, over the external malleolus,

we are dealing with a bursa which is sometimes normally present. A knowledge of the usual situations of bursæ is essential for diagnosis.

Bursæ are liable to injury, acute and chronic inflammation, tuberculous and syphilitic infiltration, and to neoplasms. They are also affected by rheumatism, gonorrhœa, and gout.

Injury.—As we have indicated, repeated slight traumatism causes a bursa to form at the irritated spot. Continued irritation leads to enlargement, or chronic bursitis, which we shall discuss presently. Moreover, a single injury may cause contusion or hæmorrhage. As to contusion we need make one remark only: A bursa, whether its contents are serous or hæmorrhagic, forms an ideal cultivation ground for bacteria, if once infected. Infection is easy through minute fissures in the contused skin, or through skin whose vitality has been lowered by injury. It is well, therefore, to treat a contused bursa by antiseptic applications.

Hæmorrhage into a bursa may or may not be accompanied by rupture of the sac wall. In the latter case the swelling is more defined than in the former; and clotting is less likely to follow if the wall is intact. Absorption generally occurs, but occasionally suppuration sets in; or, the clot, if not absorbed, may undergo organisation and form a fibroid bursa. In connection with severe injuries, blood may be effused in such quantities as to mask a severe lesion of the bone beneath; for example, fracture of the patella or of the olecranon.

The treatment of traumatic bursitis is as follows: If the bursa is wounded or lacerated, it should be thoroughly cleansed, and a gauze drain placed in it for two or three days. If there is no abrasion of the surface, a cooling antiseptic application should be put on for the first thirty-six hours and the parts kept at rest. Then hot applications may be used to assist absorption, aided by pressure and gentle friction. Should suppuration result, a free opening must be made, all the clot removed, and the wall curetted.

Chronic serous bursitis gives rise to an indolent, fluctuating swelling, free from pain and inflammation. Its form depends on its anatomical formation. Thus in the pre-patellar bursa or housemaid's knee, it is more or less spherical. In the hygroma due to the distension of the bursa between the ligamentum patellæ and the upper part of the tibial tubercle—a bursa which does not communicate with the joint by the way—it is bi-lobed, owing to compression by the ligament. Large hygromata are, as a rule, lobulated, from the formation and distension of pockets. The situations of certain

bursæ are very important from a diagnostic point of view; for example, the subacromial bursa, those under cover of the gluteus maximus, that beneath the subcrureus, which, as a rule, communicates freely with the knee-joint, and the semi-membranosus bursa. Bursæ in the popliteal space may be mistaken for aneurysm, but usually they can be partially emptied by flexing the knee and pressing some of the contents back into the joint, whilst they are unaffected by compression of the femoral artery. In doubtful cases exploratory puncture may be resorted to. When the effusion is very slight, and degenerative changes in the wall have commenced, a creaking, crepitation, or friction sensation may be felt. Thus subscapular [1] creaking has been attributed to friction in the bursa.

Treatment.—A hygroma free from pain does not require treatment unless its size or situation cause inconvenience. Tapping, injection with tincture of iodine after evacuation, or with 1 in 20 carbolic solution,[2] simple crushing, or subcutaneous incision with scarification of the inner wall, have all been frequently adopted. Hoffmann states [3] that "he has adopted the last plan in 104 cases of housemaid's knee, with immediate success in 98, and it does not necessitate an anæsthetic or the laying up of the patient, firm compression and bandaging alone being essential." The general consensus of opinion is that if active treatment is adopted, the wall should be excised.

If for any reason it is not found possible to dissect out the whole of the sac, it must be laid freely open, as much as possible taken away, and the remainder curetted and swabbed with a 10 per cent solution of chloride of zinc or with pure carbolic acid.

A **serous hygroma** may become the seat of inflammation—

I. Subacute;
II. Acute;

or undergo—

III. Hæmorrhagic degeneration;
IV. Fibroid "
or V. Become infected with tubercle.

[1] Terrillon, "Frottement sous-scapulaire," *Arch. gén. de méd.*, 1874, p. 384; Le Dentu, "Rapport sur les observations de Terrillon," *Bull. de la Soc. de Chir.*, 1876, p. 724; Favier, "Frottement sous-scapulaire," *Gaz. des hôpitaux*, 1894, p. 1109.

[2] The solutions must be drained away at once, little or none being left behind.

[3] *Amer. Journ. Orthop. Surg.*, 1904-5. These results are better than might have been expected seeing that this bursa is, as a rule, not a well-defined sac, but consists of two (a subcutaneous and a subaponeurotic, sometimes communicating) or even three sacs, generally communicating with each other, and sometimes with the joint (Bize, *Journ. d'anat. et de phys.*, 1896, p. 85).

I. **Subacute bursitis** is due to gout, rheumatism, gonorrhœa, or to repeated traumatism. Tuberculous infection must also be borne in mind. The example of subacute bursitis most frequently met with is that of painful heel or Achillodynia. The symptoms are pain (increased by use of the part), tenderness, and swelling. It is often associated with signs of recent injury to or pressure on the skin.[1]

The treatment consists of rest, counter-irritation, and fixation of the part. If milder measures do not give relief, the affected bursa must be excised.

II. **Acute suppurative bursitis** may be due to infection of a chronic hygroma. A normal bursa, however, may be directly infected by a punctured wound, by septic inflammation in the neighbouring tissues, or by lymphangitis, a bursa being simply an enlarged lymphatic space. Occasionally, but rarely, the infection may be by microbic embolism.[2] The symptoms in this case are partly local and partly constitutional. The treatment consists of free opening and curetting.

III. Volkmann has described a condition in the joints under the name of "pachysynovitis hæmorrhagica," and a similar affection in bursæ gives rise to **hæmorrhagic hygroma.** With the traumatic form, or hæmorrhage into bursæ, we have already dealt. It has been pointed out by Ombrédanne that hæmorrhagic hygroma bears the same relation to the serous form that hæmatocele does to hydrocele. The bleeding is associated with changes in the sac wall (pachybursitis hæmorrhagica), which is much thickened, to as much as half an inch. Internally there is a fibrinous stratified deposit, with here and there granulations composed of the usual embryonic cells. It is from the latter that the hæmorrhage proceeds. Hæmorrhagic hygromata may attain a very large size, even as large as an adult head. They have been seen reaching from the middle of the thigh to the upper third of the leg (Ombrédanne).

The contents are more or less altered blood clot, and degenerated tissue from the cyst wall. They are not easy to distinguish clinically from the serous form save when very large.

[1] Bursitis, both the subacute and the dry forms, may be one of the causes of the "peri-arthrite scapulo-humérale" of Duplay (*Archives gén. de méd.*, Paris, 1872). The "peri-arthrites" may be due to various causes, some of them probably merely nervous or neuralgic in character and not inflammatory at all. In the case of the shoulder, teno-synovitis of the biceps tendon, injury, rheumatism, gonorrhœa have all given rise to the symptoms described as those of peri-arthritis (Carpanetti, "Péri-arthrite scapulo-humérale," *Thèse de Paris*, 1897-98).

[2] Lebert, quoted by Ombrédanne.

IV. **Fibrous Hygroma.**—The pathogeny of the fibrous form is somewhat doubtful, and it is not clear that fibroid "degeneration" is a correct designation. Virchow calls it "hygroma proliferans," and regards the process as essentially hyperplastic, whilst Graser, Ricker, Langemak and others, although recognising the initial hyperplasia, which explains the thickness of the wall, consider the innermost or fibrinoid layer to be merely a layer of coagulation-necrosis. In accordance with this latter view, the term "hygroma destruens" has been proposed. There are certain points in favour of the degenerative idea. The sequence—repeated traumatism, hyperæmia, hyperplasia, liquefaction of the fatty tissue, and formation of an adventitious fibroid bursa—is very suggestive. And it is easy to see how the sub-varieties, fibromatous and lipomatous hygromata, may arise, according to whether the actual bursal cavity is small or the amount of fatty tissue is large. On the inner wall of a fibroid hygroma, vegetations of various kinds may be met with, fatty or more fibroid in character; villoid, papillomatous, or pedunculated in shape. If they are detached, loose bodies form.[1] There is no serous lining to the cysts. The vegetations may be explained, by the degenerative theory, as due to the survival of the more resistant parts of the cyst wall.

Calcification in a hygroma proliferans may lead to a large exostosis-like tumour. Such a case is recorded in which the patellar bursa was replaced by a calcified mass as large as a fist.[2]

Tuberculous Bursitis.—Pathologically three forms are recognisable—the mucoid or myxomatous, the hygroma with rice-grain bodies, and the fungous. The myxomatous form is excessively rare, indeed it may be regarded as a pathological curiosity.[3] The fungous variety is also rather rare. The infection may be primary, but more often is secondary to tubercle elsewhere, generally from the neighbouring joint or bone, and it is not essential that there should be any direct communication.

In the rice-grain variety the bursæ affected are, in order of frequency, the pre-patellar,[4] the subdeltoid,[5] those about the external

[1] Foreign bodies do not all arise this way; they may arise from pure traumatism. See "Exostoses mobiles et bursite traumatique de la patte d'oie," by H. Toussaint, *Rev. d'orthop.* Jan. 1905. [2] Haupt, *Zeitschr. f. orth. Chir.* xiv. p. 391.

[3] Critzmann, "Hygroma tuberculeux à type myxomateux," *Méd. mod.*, 1890, p. 638; Martin, *Thèse de Paris,* 1891.

[4] Arbuthnot Lane, however, states that the bursa patellæ appears to possess a peculiar and not easily explicable freedom from tuberculous disease. Treves, *System of Surg.* ii. p. 37.

[5] Disease of the subdeltoid gives rise to a swelling, most obvious anteriorly between

lateral ligament of the knee, the peri-trochanteric, and the subcrureal. Adventitious bursæ may also be infected. The fungating is seen chiefly in the subdeltoid and the subgluteal.[1] Ombrédanne states that the transformation from the rice-grain to the fungous form is possible, but has not yet been demonstrated.

As to the symptoms little need be said. In the rice-grain variety the characteristic sensation may be elicited. In 9 of 19 cases where the grains were present, the sensation could not be obtained (Morisson). In a case observed by Ruotte, which was made bi-lobed by a constricting band, the slipping sensation was present if fluctuation was sought for across the band, whilst if parallel to it only a sensation of fluid could be made out.

The treatment of tuberculous bursitis must be prompt and decisive. It is always advisable to ascertain, by the aid of a radiogram, if the subjacent bone is involved. In all cases the affected bursa is to be completely dissected out, with a good area of soft tissue around it, and when the bone is diseased, it is to be freely gouged away. If the glands are tuberculous, they are to be removed.

Syphilitic Bursitis.—This is met with in the serous form during the secondary stage, and in the tertiary stage as the fibroid variety, becoming gummatous. It frequently follows an injury. The seat of the affection is usually the patellar bursa. The fibroid

the deltoid and pectoralis major. Whitman states that 16 cases have been reported by Blanvelt (*Beitr. zur klin. Chir.* Bd. xxii.) and 3 by Ehrhardt (*Archiv f. klin. Chir.*, 1900, Bd. lx.); also Küster (*Archiv f. klin. Chir.* Bd. lxvii. p. 1013).

[1] Quain states: "Between the fascial insertion of the muscle and the great trochanter is a large multilocular bursa, or there may be two or three smaller ones, and another intervenes between it and the upper part of the vastus externus. In some cases there is also a bursa over the ischial tuberosity." Smaller bursæ in this region are those connected with the gluteus medius, minimus, pyriformis, obturator internus, and quadratus femoris. In an article on "Gluteal Bursitis," E. G. Brackett points out (*Trans. Ann. Orth. Assoc.* vol. x.) that the symptoms closely resemble hip-disease in its early stages, but they are less severe and not subject to the usual remission met with in early and slowly developing hip-disease. Symptoms are aggravated by exercise, the limp is early and persistent, pain is not prominent, night-cries do not occur, spasm is so slight that it may be disregarded. He relates seven cases. Early operation may prevent it spreading to the hip-joint. See also Wieting, *Deutsche Zeitschr. f. Chir.*, Sept. 1904; Zuelzer, *Deutsche Zeitschr. f. Chir.* Bd. i. Hefte 1 and 2, who deals with a collection of 45 cases of gluteal and 15 of ilio-psoas bursitis (Whitman, p. 395). In the latter the enlargement is on the upper and inner aspect of the thigh, and the limb is slightly flexed, abducted, and rotated out. Flexion, abduction, and rotation outward is also described by Lipffert as the attitude of gluteal bursitis (*Beitr. zur klin. Chir.* Bd. xl. p. 503).

form is very indolent and slow in progress, but when small it readily yields to treatment. If of large size and ulcerating, it should be removed completely by excision.

Neoplasms.—The innocent forms are fibro-enchondroma and myxoma, and the malignant forms are sarcomatous or endotheliomatous.[1]

The treatment of these neoplasms is thorough removal.

ACHILLODYNIA

Synonyms: *Achillo-bursitis, Pternalgia, Talalgia, Retro-Calcaneal Bursitis.*

Definition.—Achillodynia is a term generally applied to a painful condition about the insertion of the tendo Achillis into the os calcis. As we shall see, pain may not be limited to this area, but is found in the neighbourhood.

Varieties.—The affection is due to inflammation of bursæ. In immediate relation with the insertion of the tendo Achillis two bursæ are found, one between it and the upper part of the posterior surface of the os calcis, and another, a smaller one, between the skin and the lowest part of the tendon. Either may be inflamed, and we have—

1. Anterior Achillodynia.
2. Posterior „

Yet another bursa may form and become inflamed, viz. that between the under surface of the os calcis and the fatty tissue of the heel, and this constitutes a third variety.[2] A fourth form of Achillodynia is met with, viz. inflammation, often gouty or rheumatic, of the substance of the lower part of the tendo Achillis itself, a teno- or tendino-cellulitis.

Ætiology and Causation.—The affection is usually one of adolescence and adult life. In some cases its onset is determined by a direct injury, as for instance, a blow by a hockey stick on the back of the heel. In other cases the injury is indirect, such as a strain of the tendon occurring in running or jumping. It is also due to repeated use of the tendon as in a long bicycle ride, or is caused by the pressure of a seam in the upper part of the boot during a long walk. These are the usual causes of the acute form.

In the subacute form, a history of rheumatism, gout, or

[1] Ranke, *Arch. f. klin. Chir.*, 1886.

[2] Otherwise called calcaneo-bursitis, or hygroma souscalcanéen.

gonorrhœa exists. Sometimes the continued pressure of the shoe over the back of the heel, in persons so disposed, gradually causes swelling of the bursa. It is also associated with hyperæmia of the subjacent bone, and I have met with it three times in boys about the age of fourteen in whom no history of injury was forthcoming. I have also seen it occurring in association with rickets, and on some occasions it has come to my notice as an early symptom of the tuberculous affection of the epiphysis of the os calcis.

Symptoms.—In acute cases, pain is felt about the insertion of the tendo Achillis, and the pain is so severe that the patient can walk only on the toes. When he attempts to drop the heel the pain is sufficient to prevent him. When the anterior bursa is inflamed, swelling and sometimes redness, more particularly on the inner side of the heel, are noticeable. Fluctuation can also be obtained from one side of the tendo Achillis to the other; and as the inflammation spreads from the bursa to the neighbouring tissues, the heel is often seen to be broadened. Some crepitation may be felt as the inflammation spreads to the sheath of the tendon, due to teno-synovitis. Pain is considerable, and radiates from the heel up the leg, and the patient walks on the toes with the foot everted, so as to relax the strain upon the tendon, and to avoid increasing the tension within the bursa. In posterior Achillodynia the swelling is superficial. In the subcalcaneal form there is no tumour, only a slight puffiness can be made out, and the painful area can be localised by touch. Sometimes the pain is associated with an exostosis.

Morbid Anatomy.—In acute cases the walls of the bursa are not thickened, and the fluid is, as a rule, clear, but pus may form. In chronic cases, especially where rheumatism or gout, gonorrhœa, syphilis, or tubercle is present, the wall is much thickened, and the lining membrane shows small pedunculated processes, the contents being semi-solid or caseous. In gout, small chalk stones are found.

Treatment.—In acute cases absolute rest is essential, both local and general. The foot should be plantar-flexed and a splint applied. Counter-irritation by a blister or iodine liniment should be employed; and when the most acute symptoms subside, a plaster-of-Paris bandage should be put on for one or two weeks, and after that gentle massage practised.

In the subacute cases, Whitman recommends the application of a long and broad band of adhesive plaster from the balls of the toes around the heel to the upper third of the calf, the foot being

slightly plantar-flexed. This strip of plaster is firmly fixed by other narrow strips about the metatarsus, the heel, and the calf. Many of these cases, however, require more active treatment.

In chronic cases a constitutional cause should be sought for, and if present, relieved. Strapping with Scott's ointment (Ung. Hydrarg. Co.) and thorough rest are useful. If the patient is unable to rest, strain may be taken off the tendo Achillis by raising the heel of the boot a quarter to half an inch; and as the part is often extremely sensitive to the impact of the foot upon the ground, a piece of thick rubber should cover the heel of the boot. In many cases it is advisable to have an X-Ray photograph taken so as to ascertain if there is any tuberculous disease of the underlying bone, or to see if an exostosis is present.

Operation.—In acute cases where suppuration has occurred, and in chronic cases where tuberculous disease or an exostosis is present, or if concretions have formed within the sac, the bursa should be excised. This is better done from the inner side, and during healing the foot should be kept plantar flexed.

The posterior bursa, smaller than the anterior, usually becomes inflamed by the pressure of the shoe or from direct injury. The symptoms are not so marked as in anterior bursitis, and when the bursa becomes enlarged the fluctuation is quite superficial. As a rule, rest and relief from pressure will suffice to relieve the pain, and it is rarely necessary to excise the bursa unless suppuration has taken place, or an exostosis is present.

CHAPTER IV

INJURIES AND DISEASES OF THE FASCIÆ

Rupture—Inflammation and Sloughing—Rheumatic, Gouty, Gonorrhœal, and Syphilitic Affections of the Fasciæ—Dupuytren's Contraction of the Palmar Fascia.

A FASCIA is a fibrous envelope, enclosing muscles and holding in place other important structures.

The fasciæ in different regions of the body have received particular names, and many, if not all of them, are of surgical importance. They are arranged in two layers, the superficial and the deep, and with the latter the tendons often blend and form aponeuroses.

Rupture.—In wounds of any depth both the superficial and deep layers are involved, and they are often extensively ruptured in contusions and lacerations. If the wound can be rendered aseptic, healing of the rent in the fascia follows; but if suppuration occurs, the pus tracks extensively beneath the fascia, and travels to a considerable distance in the muscular compartments. Occasionally even in an aseptic wound the rent in the fascia fails to heal, and a hernia of muscle follows (vol. i. pp. 762-764).

Inflammation and sloughing occur in the superficial fascia in the course of cellulitis, and frequently extend to the deep layer, when large portions of it may be withdrawn from the wound as grey or pale-yellow sloughs.

Rheumatism and gout frequently affect the fasciæ, particularly of the palms of the hands and soles of the feet, and the latter parts are one of the usual sites of *gonorrhœal* inflammation. Occasionally *gummata* and *new growths*, such as fibromata and sarcomata, are met with, originating in the fascia.

Contraction of the fasciæ is of considerable importance from an orthopædic standpoint, witness the residual deformity left after the operation for wry-neck, due to shortening of the extensive

ramifications of the deep cervical fascia; also the contraction of the outer part of the fascia lata and ilio-tibial band in some cases of infantile paralysis, and in genu valgum.

Contraction of the Plantar Fascia.—Any cause which approximates the heel and the heads of the metatarsal bones results in shortening of the fascia, and causes pes cavus, or as it is better named, talipes arcuatus and plantaris (vol. i. pp. 323-328). The usual causes are talipes equinus, equino-varus, and calcaneus. Contraction is met with in some cases of Friedreich's disease, and in rheumatism, gout, and gonorrhœa. The author has twice seen contraction of the plantar fascia originate at the same time as Dupuytren's contraction of the palmar fascia.

DUPUYTREN'S[1] CONTRACTION OF THE PALMAR FASCIA

Synonyms.—English, *Contraction of the Palmar Fascia*; French, *La maladie de Dupuytren*, *Rétraction de l'aponévrose palmaire*; German, *Die Dupuytrensche Contraktur der Finger*, *Die desmogene Kontraktur*, *Dupuytrensche Kontraktur der Palmaponeurose*.

Definition.—A permanent flexion of one or more fingers arising from contraction of the palmar fascia, and its digital prolongations.

Occurrence and Ætiology. *Sex.*—Males are much more frequently affected than females. In Adams'[2] experience the proportion was 15 or 20 to one; Lancereaux met with 5 females in 81 cases. In the cases collected by W. W. Keen of Philadelphia, of those in which the sex was noted, 180 were men and 40 women, but such a comparatively high proportion of females is not in accordance with the general experience.

Age.—It is an affection of middle and later life; that is, over 40 years of age and more. In young people it is quite exceptional, but I have seen it in a girl of 16, and in a man aged 28 years. From Noble Smith's[3] investigations in certain of the metropolitan workhouses, it appears to be more frequent in old people of either sex than is usually supposed.

[1] Dupuytren, "De la rétraction permanente des doigts, et du diagnostic différentiel," *Leçons orales de clinique chirurgicale*, Bruxelles, 1839, p. 473.

[2] W. Adams, *Further Observations on the Treatment of Dupuytren's Contraction*, London, 1890; *Finger-Contraction and Hammer-Toe*, 2nd ed.; *Lancet*, 1877, vol. p. 838; *B.M.J.*, June 29, 1878.

[3] *Royal Med. Chir. Trans.*, 1884; *Trans. Am. Orth. Assoc.* vol. xiv.

Heredity.[1]—Keen[2] found this factor in 50 of 198 cases; in three of them it occurred in three generations, and once in four.

Occupation.—The contraction occurs in those who use the palm of the hand much in daily work, *e.g.* carpenters, engravers, gardeners; also in those whose occupation entails keeping the fingers much flexed, *e.g.* writers, pianists. It is met with, however, still more often in cases where no such cause can be suggested—or, it may be seen bilaterally in a person whose occupation entails the use of one hand only.

Traumatism.—It has been seen after a single traumatism such as a fall on the hands with the fingers spread out. In this connection, one case of our own and one of Abbe's are of interest.

CASE 26. T. R. P., aged 56 years, caught the little finger of the right hand in a door two years previously. For a time it was very painful and considerably swollen, and when the swelling had passed off he noticed a "leader" at the root of the little finger, where there had not been one previously. On examination, a typical Dupuytren's contraction in the early stage was seen, which was relieved by subcutaneous section.

CASE 27. A patient of Abbe's[3] attributed his condition to a strain whilst turning on a stopcock some years previously, when he experienced a snap as if something were breaking in the palm. The part became puffy and then the swelling slowly disappeared, the palmar contraction following fifteen months afterwards.

In other cases the rough usage has been more prolonged. Thus a civil engineer had to put a long series of stakes into the ground, and pressed them hard with his palm. Next day he had a sore palm and traced the contraction directly back to this. It has also followed the use of an alpenstock in a strenuous mountain tour, as reported by Vogt and Tillmanns.[4]

As a rule, however, the traumatism is of a more chronic character. Thus a chemist consulted us for Dupuytren's contraction. In the transverse crease of the left palm and in a line with the ring finger there was a hard nodule, whilst a band passed down to the ring finger, which was slightly flexed. For many years the spot where the nodule was seen had been pressed in using

[1] Bulley, *Med. Times and Gazette*, 1864, ii. 218; Madelung, *Berl. klin. Woch.*, 1875, xii. 291; Adams, *B.M.J.*, June 29, 1878.

[2] Quoted by Adams in his pamphlet on *Further Observations on the Treatment of Dupuytren's Contraction*, London, J. and A. Churchill, 1890; also *Finger-Contraction and Hammer-Toe*, 2nd ed. p. 85.

[3] Abbe, *New York Med. Journ.*, 1884, No. 16; *ibid.* 1894, Jan. 13.

[4] Joachimstal's *Handbuch*.

the pestle and mortar in pill-making. There was also a history of gout.

In many patients careful palpation reveals the presence of little nodules in the affected palmar fascia. Heuser[1] collated the records of 261 cases, and in 148 of them there was evidence of such nodules. Probably they are cicatricial in character, and are preceded by slight rupture of the fascial bands. Ledderhose[2] agrees with this view. The important point on which information is withheld is whether the cases where nodules were found were in individuals who laboured with the hands.

Digits affected.—Generally the ring finger is first affected, and then the little finger becomes involved,[3] and later the middle finger. Occasionally the thumb or index is contracted.[4] Flexion occurs first at the metacarpo-phalangeal joint, subsequently at the first interphalangeal joint, and later at the second.[5]

Often both hands are involved, but not simultaneously, nor to an equal degree; and the preponderance of the affection in the right hand[6] is not so great as to support fully the theory of production by traumatism.[7]

Causation.—From the above considerations it is clear that a fairly strong case can be made out for the traumatic factor. The greatly increased frequency of the affection in advanced age,[8] however, its occurrence bilaterally, the fact that the number of right-handed

[1] Heuser, *Beitrag zur Frage, "Dupuytrensche Kontraktur und Unfall"*; Diss., Bonn, 1904.

[2] Ledderhose, Langenbeck's *Archiv*, Bd. 102.

[3] According to Vogt, this is because the 4th and 5th fingers are used more energetically in grasping than are the other fingers, and the corresponding palmar aponeurosis is more subject to injury.

[4] In an analysis of 105 cases—

The thumb was affected	9 times
The forefinger	13 ,,
The middle finger	45 ,,
The ring finger	88 ,,
The little finger	77 ,,
The ring and little fingers together	65 ,,

[5] In 73 cases, the first phalanx was affected in 15, the first and second in 45, the second alone in 7. The third phalanx was also involved in 6.

[6] In 184 cases of Keen's, the right hand only was attacked 58 times, the left 23, and both hands 103 times.

[7] The author has on two occasions seen contraction of the plantar fascia associated with Dupuytren's contraction in both hands.

[8] That is, at the time when fibroid changes generally supervene. Cases are recorded in which Dupuytren's contraction and narrowing of the orifice of the prepuce have been seen in the same elderly person. The disappearance of the fat in the palm occasioned by old age may render the fascia more liable to chronic traumatism.

cases is not excessive, and that in so many cases where, from the occupation and history, traumatism of any sort is inadmissible, together with the marked hereditary tendency, indicate that traumatism alone is not the only cause. And certain other considerations strengthen this view. It is universally conceded that a history of gout or rheumatism[1] is frequently met with in these cases.[2] Thus of 48 cases in Keen's tables, 42 had either a personal or family history of gout or rheumatism; and W. Adams stated that in his experience the affection was found to be more common among butlers and indoor servants than in those who performed manual labour. With reference to the cases occurring in the professional classes, he says the only condition common to the whole series is a disposition to gout. Still, it must be admitted that in many cases the actual manifestations of gout are not very definite.[3]

Dupuytren's contraction may also be a tropho-neurotic manifestation of central origin. Thus it is met with in tabes,[4] multiple sclerosis, syringomyelia, arterio-sclerosis, and local spinal lesions. Testi [5] records the affection as occurring in three brothers, in one of whom the post-mortem examinations showed marked syringomyelia. Manizer [6] saw it come on in a man aged 52 years, three months after an injury to the cervical spine. Jardini [7] described a case which he attributed to arterio-sclerosis affecting the central grey matter of the cord. Abbe inclines to the nervous view. He states the sequence of events to be, "First, a slight traumatism occurs, often entirely forgotten; then a spinal impression, produced by this peripheral irritation, succeeded by a reflex influence on the part

1 Or the somewhat vague condition described as "arthritisme" by French writers.

2 See also Poncet, "Rheumatisme tuberculeuse articulaire; rétraction de l'aponévrose palmaire d'origine tuberculeuse," *Annales de chir. et d'orthop.*, 1904, No. 3.

3 Paget's *Minor Manifestations of Gout*. Mr. Lockwood, in the discussion on Mr. Adams' paper at the Medical Society in May 1890, stated that he had made a necropsy in a case in which there was general gouty disease of the joints, where too the fascial contractions were found to be incrusted with urate of soda.

4 Bieganski, "Die spontane Kontraktur der Finger als ein trophischer Prozess zentralen Ursprungs," *Deutsche med. Wochenschr.*, 1895, No. 31; Neutra, "Zwei Fälle von Dupuytrenscher Fingerkontraktur bei Tabes mit multipler Sklerose," *Wiener klin. Wochenschr.*, 1903, No. 2.

5 Testi, *Riform. med.*, 1905, 30.

6 Manizer, "Ein Fall von Dupuytrenscher Fingerkontraktur mit spinal-traumatischer Ätiologie," *Münchener med. Wochenschr.*, 1905, No. 44.

7 Jardini, "Morbo di Dupuytren arteriosclerosi midollare," *Il Morgagni*, Parte i., No. 4, 1907; also Megis, "Maladie de Dupuytren, Paralysie générale, Arthritisme," *Gaz. méd. de Paris*, 1887.

originally hurt, producing in its turn pain, hyperæmia, hypertrophy, and contraction of the bands of the fascia; and occasional joint lesions simulating subacute rheumatism." These statements assume too much and are incapable of proof.

The affection is relatively frequent in diabetics.[1] Teschemacher[2] found it 33 times in 213 cases of diabetes, and considered it a tropho-neurotic change, but it seems more reasonable to ascribe it to abnormal metabolism. That these disorders may be of great importance is suggested by those cases which have benefited by appropriate medical measures.[3] An important point is the necessity of an examination of the urine before undertaking any considerable operative procedure.

Ricard and Ricket record cases in syphilitic subjects in which the affection yielded to iodide of potassium; and the author has seen three cases in syphilitic subjects, but they did not yield to the usual remedies, and required operation.

Lastly, William Anderson, in his Hunterian Lectures, remarked: "The situation of the initial lesions and the peculiar tendency of the new growth to feed like a parasite upon the tissues in which it spreads and which it replaces, have led me to believe strongly that the active agent of destruction is a specific micro-organism which gains access to the subcutaneous tissues through accidental lesions of the epidermis, mostly effected by the finger-nails. This would explain far better than any existing hypothesis the persistent cause of the disease, and its proneness to recur after the most skilfully-devised operations." The author has endeavoured on six occasions to demonstrate the presence of micro-organisms in excised portions of the affected fascia, and has failed.

To sum up, Dupuytren's contraction appears to be a fibrosis due to senility, tropho-neurotic changes, or metabolic affections, and is encouraged in many cases by traumatism.

Morbid Anatomy.—The exact nature of the affection has been made very clear by numerous dissections, references to which are given below.[4]

[1] Viger, *El Siglo med.*, Sept. 14, 1884.

[2] Teschemacher, "Über das Vorkommen der Dupuytrenschen Fingerkontraktur bei Diabetes Mellitus," *Deutsche med. Wochenschr.*, 1904, No. 14.

[3] Ferrari, "Considerazioni sopra un caso di malattia di Dupuytren guarito con cura medica locale," *La Riforma medica*, 1906, No. 15; Noble Smith, *Trans. Am. Orth. Assoc.* vol. xiv. pp. 325, 326.

[4] Dupuytren, *Leçons orales de clinique chirurg.*, 1832, and *London Med. and Surg. Journ.* vol. i. p. 267; Goyrand, *Médicale de Paris*, 1835, p. 481, and *Mémoires de*

The points to be borne in mind are: (1) The affection is primarily a contraction of the fascia, and secondly, of the skin. The tendons have nothing to do with it. (2) The palmar fascia is not a well-defined aponeurosis. It fades off gradually at its edges. (3) It gives off two sets of processes, the superficial in the form of numerous bands, which are intimately connected with the skin; and the deep to the lateral aspect of the fingers, which pass to the sides of the first and second phalanges, to the periosteum, and to the tendon sheaths. (4) The nature of the change in the fascia is a fibroid hypertrophy. In some cases this appears to be local, and to affect the fascia in the form of small fibromata or nodules. In other cases, however, it is a general hyperplasia of one or more bands followed by contraction. (5) The skin and fascia are so closely united by numerous bands that dissection back of skin-flaps is difficult. The reason why the ring finger is more often affected is pointed out by Reeves. In flexion of the fingers, the deepest part of the palm corresponds with the ring finger, and it is this part of the palm which is most compressed in grasping or pushing a round or circular body.

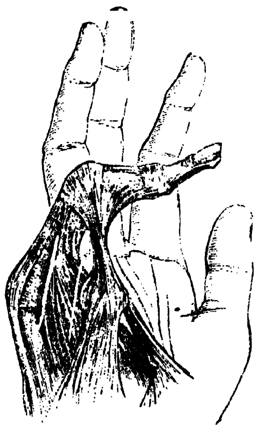


FIG. 596.—A Dissection illustrating the Contraction of the Palmar Fascia and its Prolongations in Dupuytren's Contraction (after Druitt).

Variot found that the fat of the palm had disappeared in one case, and that the palmar fascia and subcutaneous tissue, the latter being thickened, were continuous.[1] He also described hypertrophic changes in the deeper layers of the skin and thickening of the walls of the sweat-glands. Madelung[2] thinks that the disappearance of the fat of the palm is the first stage, and is occasioned by old

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l'Académie royale de méd. tome iii., and *Gaz. méd.*, 1834, p. 219; Partridge, *Path. Soc. Trans.*, 1853-54, vol. v. p. 343; Druitt, *Surgeons' Vade-mecum*, 11th ed. p. 301; Sevestre, *Journ. d'anat. et de phys.*, Paris, 1867, iv. p. 249; *St. Bartholomew's Hosp. Catalogue*, vol. i. p. 177, Churchill, 1882; Lockwood, *Path. Soc. Trans.* vol. xxxvii. p. 556; Ricket, *Prog. méd.*, 1877; Ménard and Variot, *Thèse de Paris*, 1881; W. Adams, *Finger-Contraction and Hammer-Toe*, 2nd ed., 1892, p. 12; Lancereaux, quoted by Reeves, *Bodily Deformities*, p. 358; Madelung, *The Causes and Treatment of Dupuytren's Contraction*, Trübner's Translation, 1876.

[1] This observation has been repeatedly confirmed by the writer in performing the open operation.

[2] Madelung, "Die Ätiologie und die operative Behandlung der Dupuytrenschen Fingerkrummung," *Berl. klin. Wochenschr.*, 1875, 15 and 16.

age, traumatism, and inflammation. When the fat has atrophied, the palmar fascia is more subject to irritation from injury or repeated traumatism, especially over the heads of the metacarpal bones, hence the thickening. In old-standing cases, secondary contraction of the flexor tendons and joint capsules occurs.

Symptoms.—At first there is a feeling of tightness in the palm of the hand or in the ring or little finger, and the patient finds some difficulty in extending the fingers fully, and later there may be seen some nodular indurations in the palm opposite the heads of the metacarpal bones. There is often considerable neuralgic pain in the hand. The skin is at first quite movable on the indurations,

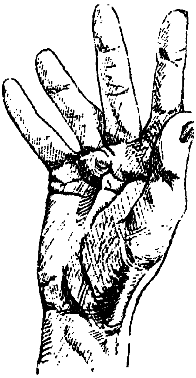

FIG. 597.

FIG. 598.

FIG. 599.

Three figures illustrating three stages in Dupuytren's Contraction (Fig. 597 is after Rédard).

but later it becomes adherent, dry, and thickened, and a puckered depression appears in the transverse crease. The affected fingers then begin to retract in this order; the first phalanx on the metacarpal, and the second on the first. As a rule the third remains extended on the second; but in the last stage, when the finger is much pressed into the palm, the terminal phalanx is flexed (Figs. 597, 598, 599). As the skin adheres in the palm, fibrous bands, like bow-strings, make their appearance, and stand out, and they can be traced to the lateral aspects of the fingers. In some cases the fibrous bands first appear in the fingers. The affection may progress rapidly or slowly. Adams states that he had known the tip of the finger to be so drawn down as to touch the palm in two years.

Prognosis.—Although the affection is usually slow in its progress, it is continuous, and a wound in the palm may be ultimately caused by the nail of the flexed finger. Rarely does it become spontaneously arrested.

Diagnosis.—1. From congenital contraction; the points of distinction have been tabulated on p. 89.

2. From contraction of the tendons, the result of hemiplegia or of nerve lesions in the forearm: In these cases there are no fibrous bands in the palm, as in Dupuytren's contraction. And in the latter affection the presence of nodules and the adhesion of the skin serve as distinguishing points. In Dupuytren's contraction the tendons above the wrist may be felt to move freely on passive extension of the fingers. Then in nerve-lesions, wasting either of the thenar or of the hypothenar eminences, or both, is present.

3. From flexion of the fingers due to adhesion of the tendons to the sheaths: It is found that, on passive flexion, the affected tendons are immovable both in the finger and above the wrist. After deep whitlows, if the tendon sheath has been widely opened, the tendon stands up in the palm of the hand. And passive extension obliterates the prominence instead of increasing it, as in Dupuytren's contraction.

4. From contraction of the hand due to osteo-arthritis: The writer has seen all the fingers in this affection bent into the palm, and the whole fascia indurated. In this case, however, there were no distinct bundles of fascia, and no one portion of the fascia was affected more than the other.

Treatment.—When the affection is at all marked, the only measure available is an operation on the fascia. Attempts have been made by gradual mechanical extension to overcome the contraction, but they have always been painful and unsuccessful, and the contraction appears to have increased afterwards. In the mildest cases, extension of the fingers may be practised by the patient, only with the hope of deferring, not avoiding, operation.

In cases not suitable for operation, injections of fibrolysin once a week, commencing with 5 minims and later using as much as 30 minims, are certainly followed by softening of the contracted bands and increased mobility in the fingers. It is wiser not to inject the fibrolysin into the palmar fascia because of the pain and probable sloughing. The shoulder or the back are the best places.

Operative Treatment.—This is either subcutaneous or open. Of the subcutaneous methods the best is that of W. Adams. It

consists of making multiple subcutaneous divisions of the fascia and its prolongations. That surgeon "introduces a fascia knife with a straight cutting edge terminating in a point, and carrying it between the skin and the contracted cord, which is divided by cutting downwards very slowly and cautiously, taking care not to dip the point nor divide any of the structures except the contracted band of fascia. The first puncture should be made in the palm of the hand, a little above the transverse crease and where the skin is not adherent to the fascia. The second puncture should divide the same cord as the first, thus leaving the contracted band isolated in the palm of the hand. The third and fourth punctures divide the lateral bands,

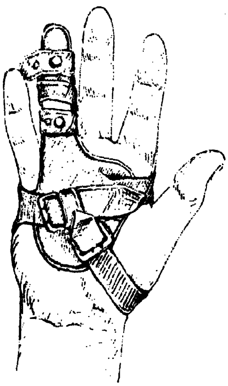

FIG. 600.

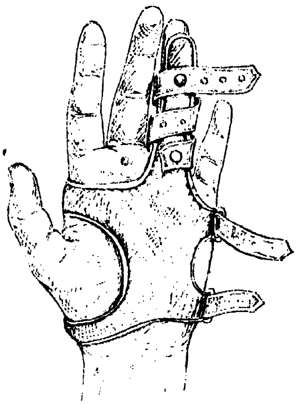

FIG. 601.

Two Forms of W. Adams' Metal Splint for use immediately after Section of the Palmar Fascia for Dupuytren's Contraction.

which pass to the fingers, taking care not to divide the nerves and arteries. Pressure is made after each puncture by a piece of porous india-rubber or German felt," or better still by pledgets of cyanide gauze.

After the operation, the finger is brought as nearly as possible into the fully-extended position without using any force, and retained thus by a well-padded metal splint (Figs. 600 and 601), applied to the flexor aspect. Full extension is not always possible, on account of the risk of tearing the skin in severe cases, and the intense pain set up by the traction on the digital nerves. In such cases it is better to make many punctures, twenty or thirty, and to extend the finger gradually. The after-treatment advocated

by W. Adams is to use the metal splint for three or four days, and then to wear the extension-instrument (Fig. 602), at first, night and day for a fortnight. When the extension is complete, it should be worn at night only for about six months. The Adams operation is often satisfactory, but it must be admitted that relapses occur.

Open Methods of Operating.[1]—All forms of open operations should be done with antiseptic precautions. Dupuytren operated by a transverse incision through the skin and contracted fascia in two or three places. Goyrand[2] incised the skin longitudinally over the fibrous bands, freeing the skin from the latter, dividing them transversely and placing the fingers in extension. Ricket modified this plan by making short transverse incisions at the end of the longitudinal one, dissecting up the small flaps thus formed as far as was necessary, and then dividing or excising the bands. Busch's[3] operation consisted of making a triangular flap with its base in the transverse crease of the palm, and the apex at the highest point of the hand. The flap, with as much subcutaneous tissue as possible, is dissected up, thus severing all the process of fascia attached to the skin. The offending bands are made prominent by pulling on the fingers, and are then freely divided. The disadvantages of this operation are the great retraction of the flap, which leaves a large surface to granulate up, and owing to the affected fascia not being removed, recurrence is probable.

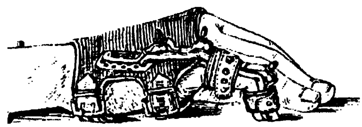

FIG. 602.—W. Adams' Extension Apparatus for use after Section of the Palmar Fascia.

Recurrence of the deformity after operation is most frequently due either to persistence in that form of occupation from which the conditions arose, or to want of persevering and watchful after-treatment. The essentials of after-treatment are thorough extension of the fingers for at least three months, and assiduous massage of the joints and passive movements to prevent stiffness, and the use of thiosinamin. As a rule cases once thoroughly and efficiently treated are cured permanently.

[1] For the respective merits of the subcutaneous and open operations, a paper on "The Treatment of Dupuytren's Contraction of the Palmar Fascia," by J. Macready, in the *Brit. Med. Journ.*, 22nd Feb. 1887, may be consulted with advantage.

[2] Cf. a modification of this operation by Mr. Hardie of Manchester, *Med. Chronicle*, vol. i. p. 9.

[3] *Berl. klin. Wochenschr.*, 1875, 15 and 16.

Treatment by the Open Operation.—Whilst the subcutaneous operation, in competent hands, gives fairly good results, yet there are certain drawbacks to it. These are the possibility of recurrence, with extension of the morbid process to other fingers, the necessity in severe cases of operating in stages, the length of after-treatment, and the expense of the apparatus required. On these grounds I have in suitable cases adopted the open method. It is found that the liability to recurrence is greatly lessened, since by a free dissection all the affected parts can be removed; and, with regard to apparatus, a simple malleable iron splint, bent or straightened as the case requires, is all that is needed. As a rule the wound is healed in a few days, and the hand regains its entire functions.

The essence of the operation is complete asepsis from first to last, and no precautions must be relaxed until every scab has come away from the wound. To avoid every possibility of septic trouble the process by which the hand is sterilised should extend over at least two days before the operation, and the surgeon should attend to all the details himself. In the case of the horny hands of the sons of toil, it is essential to soften the epithelium by the application of a weak solution of caustic potash. In dealing with the softer skin of other classes, it is sufficient to scrub the hands and fore-arms well with soft soap or with ether-soap, then with turpentine, followed by methylated spirit, and finally to keep the parts bound up for twelve hours in a solution of 1 in 2000 biniodide of mercury. The writer asks for some indulgence in dwelling upon these points, but he does so with the definite object of enforcing the statement that the key-note of this operation is asepsis first and last.

In conducting a delicate dissection in the palm, an Esmarch bandage is useful, as the parts bleed freely from numerous small points.

When there is considerable contraction of the fingers, the operation should consist of two parts, namely, the open method for the palm, and the subcutaneous method for the fingers. It is not as a rule advisable to attempt to remove by dissection the contracted bands of the fingers, more especially at the transverse folds. If the skin here is freely divided, considerable gaping of the wound follows, cicatricial tissue forms, and some loss of mobility results. Even when nodules are present on the flexor aspect of the fingers the subcutaneous method answers very well. We have found it advisable to insert the tenotome several times into large fibrous masses here, and turn the knife round freely, thus breaking up the

fibrous tissue considerably. In many cases extraordinarily rapid diminution and subsequent disappearance of large fibrous masses has taken place.

The operation in the palm is carried out by a straight incision, just below the superficial palmar arch, and passing downwards to nearly as far as the web of the fingers, and made over the most prominent band of fascia. If the affected tissue is of wide extent, two cross incisions may be made, one at either extremity of the longitudinal incision. The flaps so made are dissected back, leaving the indurated fascia exposed. This is dull white, often of cartilaginous hardness, and contrasts with the pearly white lustre of the neighbouring healthy fascia. Great care should be taken not to buttonhole the skin flaps. The digital nerves issuing from beneath the palmar fascia should then be sought for and carefully defined. The whole of the affected fascia in the palm can be dissected away, and if recurrence is to be prevented, the dissection must be carried well into the healthy tissue. Any want of care on this particular point leads to trouble afterwards.

The arrest of hæmorrhage after removal of the Esmarch bandage is best effected by twisting the larger bleeding points, and checking the oozing by the pressure of a hot sponge. Silk or other ligatures should be avoided, as they are likely to give rise to trouble in the palm, owing to non-absorption. Complete arrest of hæmorrhage is a matter of importance. If the skin flaps are sutured together, and oozing is still going on, a good deal of thickening results after the operation, and this is most undesirable.

After the removal of the affected fascia in the palm, the fingers can in all cases be considerably straightened, but further extension may be obtained by multiple subcutaneous divisions of the fascia on the flexor aspects and sides of the fingers. If nodules are present, they should be broken up with a knife in the way previously described.

In suturing the palm-wound a very careful adjustment of the edges must be made, and the best material is fine horsehair. The hand is then dressed, the fingers are extended as far as they will go, and a malleable iron splint applied on the flexor aspect of the forearm, hand, and fingers. The dressing is left for at least six days, and then the wound will be found nearly healed. On the eighth day the stitches are removed, and on the tenth day gentle movements of the fingers are carried out, and every effort made to secure full extension. A collodion dressing is kept on the palm until the

wound is absolutely healed and there is no crack whatever in the skin.

In the *Transactions of the American Orthopedic Association*, vol. xiii. page 152, I have described three cases in which this method proved most successful. In one of them, an instance of Dupuytren's contraction occurring in a patient suffering from constitutional syphilis, large squamous syphilides were present in the palms of the hands at the time of operating.

FIG. 603.—A case of Dupuytren's Contraction (A.H.T.).

FIG. 604.—The same, after dissecting away the affected Palmar Fascia, and the Application and Injection of Fibrolysin (A.H.T.).

I have now performed the open operation sixteen times, with complete success in twelve, and partial in four. In no one case of the twelve has recurrence taken place, even years after. In the four partially successful cases the scar thickened somewhat afterwards, but the affected fingers remained freely movable, and their condition was greatly improved by the operation. I can confidently recommend the open method, especially if it is supplemented by the application of thiosinamin.

The open operation[1] is not suitable for broken-down patients, nor those suffering from renal or cardiac disease, or glycosuria, nor for those too far advanced in age; but there is no reason for refusing to perform it in a healthy elderly individual.

In recurrent cases, especially after the subcutaneous operation, and four times after the open operation, I have employed fibrolysin, which is a 40 per cent solution of thiosinamin.[2] It was tried in three ways: by injecting 5 minims beneath the skin of the back, by injecting the same amount into the contracted fascia in the palm, and by making multiple incisions with a fine tenotome through the skin and contracted fascia, and rubbing fibrolysin freely into the wounds. Of these methods the last one alone gave satisfactory results. In one case, where the recurrence was extensive, and the fascial mass very thick and indurated, all the growth disappeared in fourteen days, leaving the palms soft and supple. Four times during the open operation, I have rubbed fibrolysin vigorously into the open wound, and injected a few minims at different spots around the wounds. I am entirely pleased with the results, and am disposed to believe that I have now found a method of completely restoring to the patient a supple palm and useful fingers, without fear of recurrence. The fibrolysin causes very little or no inflammatory reaction during the healing of the wound.

[1] Certain continental writers suggest that extensive dissection back of the skin may lead to gangrene, and prefer more restricted and repeated operations. Bäärnhielm (*Hygiea*, 1905, No. 7) utilises Thiersch's grafts to cover any gap left. Berger and Banzet, on account of the supposed difficulty of raising palmar skin-flaps, without hopelessly damaging them, have attempted an Italian plastic operation, to replace the fascia and skin excised. But the skin difficulty is less than these writers suggest. Tricomi has removed the entire palmar aponeurosis by means of a single incision, from the annular ligament to the first phalanx of the ring finger (*Archivio di ortopedia*, A. xxiv. No. 1).

[2] Langemak advocates a preliminary treatment by thiosinamin, and believes that subsequent operation is rendered less severe.

Thiosinamin.—Lengemann injects daily a Pravaz syringeful of thiosinamin 2 parts, glycerine 4, and distilled water 14 (Lengemann, "Unblutige Behandlung der Dupuytrenschen Fingerkontraktur," *Deutsche med. Wochenschr.*, 1903, No. 23). Langemak (*Münchener med. Wochenschr.*, 1907, No. 28) begins with 2 cc. of a 10 per cent solution. He combines this with the hot-air bath, massage, and *brisement forcé*. The needle must always be pushed through the skin into the subcutaneous tissue, or necrosis may result, and before attempting treatment the urine must be examined for sugar.

INDEX OF AUTHORS QUOTED IN TEXT[1]

ABBREVIATIONS:—Cong. = congenital; displ. = displacement; tal. = talipes; anat. = anatomy.

[1] The names of authors referred to in the footnotes are not indexed.

INDEX OF SUBJECTS

ABBREVIATIONS :—Anat. = anatomy ; T. = talipes ; cong. = congenital ; int. = internal ; ext. = external ; disloc. = dislocation ; T. eq. = talipes equinus ; T. calc. = talipes calcaneus ; T. var. = talipes varus ; T. valg. = talipes valgus ; T. eq.-var. = talipes equino-varus ; T. eq.-valg. = talipes equino-valgus ; T. calc.-valg. = talipes calcaneo-valgus ; T. calc.-var = talipes calcaneo-varus ; inf. paral. = infantile paralysis.

END OF VOL. I

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